Telecom Regulatory Authority of India

Recommendations

on

Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz, 3400-3600 MHz Bands

1st August 2018

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Contents

CHAPTER–I: INTRODUCTION

1.1 The Department of Telecommunications (DoT), vide its letter dated 19th April 2017 **(Annexure-1.1)**, informed that the Government is planning to auction the right to use of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands in the next auction. DoT requested the Authority to provide its recommendations on applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum in these bands for all service areas under the terms of clause 11(1)(a) of TRAI Act 1997 as amended.

1.2 The Authority, vide its letter dated 15th May 2017 sought additional information/clarification on some of the issues from DoT. However, to speed up the process, the Authority issued the Consultation Paper on 28th August 2017 based on the available information. Subsequently, DoT vide its letter dated 7th September 2017 provided additional information /clarifications. Thereafter, vide its letter dated 23rd July 2018 **(Annexure-1.2)**, DoT provided additional/updated information, as sought by the Authority.

BACKGROUND

1.3 Spectrum assignment in 800 MHz, 900 MHz and 1800 MHz was done administratively till 2008, while spectrum in 2100 and 2300 MHz bands was assigned through auction mechanism for the very first time in 2010. After the Hon'ble Supreme Court of India judgment dated 2nd February 2012, spectrum assignment for access services in all the bands is being done through auction process. Since 2012, total five auctions have been held for assignment of spectrum in various access bands. A summary of the spectrum auctioned in various access spectrum bands since 2012 is given in the Table 1.1.

Table 1.1

Access Spectrum Auctions conducted in India since 2012

Sl. No.	Year	Spectrum bands	Spectrum put to auction	Spectrum sold
1.	November 2012	1800 MHz (paired)	295 MHz	127.5 MHz
		800 MHz (paired)	95 MHz	No bidder
2.	March 2013	900 MHz (paired)	46 MHz (Delhi, Mumbai and Kolkata LSAs)	No bidder
		1800 MHz (paired)	57.5 MHz (Delhi, Mumbai, Karnataka and Rajasthan)	No bidder
		800 MHz (paired)	95 MHz	30 MHz
3.	February 2014	900 MHz (paired)	46 MHz (in 3 LSAs - Delhi, Mumbai and Kolkata)	46 MHz
		1800 MHz (paired)	385 MHz	307.2 MHz
4.	March 2015	800 MHz (paired)	108.75 MHz	86.25 MHz
		900 MHz (paired)	177.8 MHz	168 MHz
		1800 MHz (paired)	99.2 MHz	93.8 MHz
		2100 MHz (paired)	85 MHz (5 MHz in 17 LSAs)	70 MHz
5.	October 2016	700 MHz (paired)	770 MHz (35 MHz in 22 LSAs)	No bidder
		800 MHz (paired)	73.75 MHz (in 19 LSAs)	15 MHz (in 4 LSAs)
		900 MHz (paired)	9.4 MHz (4 LSAs-Bihar, Gujarat, UP(E), UP(W))	No bidder
		1800 MHz (paired)	221.6 MHz (in all LSAs except Tamilnadu)	174.8 MHz (in 19 LSAs)
		2100 MHz (paired)	360 MHz (20 MHz in 6 LSAs, 15 MHz in 16 LSAs)	85 MHz (in 12 LSAs)
		2300 MHz (unpaired)	320 MHz (20 MHz in 16 LSAs)	320 MHz
		2500 MHz (unpaired)	600 MHz (40 MHz in 8 LSAs, 20 MHz in 14 LSAs)	370 MHz (in 20 LSAs)

1.4 In the last spectrum auction, held in October 2016, entire 770 MHz in 700 MHz band, 58.75 MHz in 800 MHz band, 9.4 MHz in 900 MHz

band, 46.8 MHz in 1800 MHz band, 275 MHz in 2100 MHz band, 230 MHz (unpaired) in 2500 MHz band remained unsold. Spectrum refarming & harmonization process and expiry of licences in a few LSAs are likely to result in availability of additional spectrum in some of the bands. In the present reference dated 19th April 2017, DoT has proposed to auction spectrum in these bands again. In addition, DoT has included two more bands i.e. 3300-3400 MHz and 3400-3600 MHz. LSA-wise details of the spectrum availability has been discussed in Chapter-II.

CONSULTATION PROCESS

1.5 The Authority issued Consultation Paper on the subject on 28th August 2017, wherein specific issues related to timing for auction, block size, spectrum cap, roll-out obligations and various valuation methods for estimation of reserve price of spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands were raised. Written Comments on the Consultation Paper were invited from the stakeholders by 25th September 2017 and counter-comments by 3rd October 2017. However, considering the requests from the stakeholders, the last date for submission of comments and counter comments was extended till 6th November 2017 and 13th November 2017 respectively. The Authority received comments from 21 stakeholders, which are available on TRAI's website www.trai.gov.in. An Open House Discussion (OHD) was conducted on 18th January 2018.

STRUCTURE OF THE RECOMMENDATIONS

1.6 The Recommendations have been divided into four Chapters. The current Chapter provides a brief background to the subject. The

second Chapter discusses the availability of spectrum, roll-out obligations, spectrum cap, preferable block-size for auction etc. The third chapter deals with the valuation and reserve price of spectrum. The list of recommendations has been made in fourth Chapter.

CHAPTER-II: AUCTION RELATED ISSUES

A. SPECTRUM AVAILABILITY

2.1 This section discusses the availability of spectrum in the various access spectrum bands viz. 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands.

700 MHz (703-748 MHz/758-803 MHz)

2.2 700 MHz band is a sought after band for LTE deployment around the world due to its efficiency and higher penetration inside buildings. LTE device eco-system is developing fast in this band. Adoption of the APT700 MHz band plan for LTE network deployments in markets across the APAC, Latin America regions and in Europe represents a major opportunity for near-global spectrum harmonisation which will result in greater economies of scale for devices, capacity for mobile broadband services, and for roaming.

2.3 In the auction held in October 2016, 770 MHz (35 MHz in each LSA-713-748 MHz for uplink and 768-803 MHz for downlink) paired spectrum in the 700 MHz band was put to auction. No bid was received for the spectrum in this band. Therefore, entire spectrum (770 MHz) is available for auction.

800 MHz Band (824-844 MHz/869-889 MHz)

2.4 In the auction held in October 2016, a total of 73.75 MHz spectrum in 19 LSAs was put to auction in the 800 MHz band, out of which, 15 MHz spectrum in 4 LSAs was sold. The remaining unsold 58.75 MHz spectrum in 19 LSAs is available for the forthcoming auction. Details of availability are given below:

Table 2.1

Spectrum availability in 800 MHz Band

LSA	Total spectrum put in Oct 2016 auction	Spectrum sold	Spectrum that remained unsold	Total spectrum available for auction
	A	B	C=A-B	D=C
	MHz	MHz	MHz	MHz
DEL	2.5	0	2.5	2.5
MUM	5	0	5	5
KOL	2.5	0	2.5	2.5
MH	7.5	0	7.5	7.5
GUJ	6.25	5	1.25	1.25
AP	7.5	0	7.5	7.5
KTK	2.5	0	2.5	2.5
TN	2.5	0	2.5	2.5
KL	2.5	0	2.5	2.5
PB	6.25	3.75	2.5	2.5
HR	1.25	0	1.25	1.25
UP (W)	2.5	0	2.5	2.5
UP (E)	3.75	1.25	2.5	2.5
RAJ	7.5	5	2.5	2.5
MP	2.5	0	2.5	2.5
WB	1.25	0	1.25	1.25
HP	3.75	0	3.75	3.75
BH	2.5	0	2.5	2.5
OR	3.75	0	3.75	3.75
AS	0	0	0	0
NE	0	0	0	0
J&K	0	0	0	0
Total	**73.75**	**15**	**58.75**	**58.75**

2.5 DoT has informed that in WB LSA, three carriers are available in 800 MHz band; however, 2 carriers are available without guard band and only 1 carrier is available with guard band of 0.3 MHz, which was put to auction in the year 2016. Due to non-availability of inter-operator guard band, these two carriers are not proposed to be auctioned. This will result in keeping this valuable spectrum idle. From the information on carrier assignments provided by DoT, it is seen that the guard band requirement can be reduced in this band if the

spectrum holding of TSPs is made contiguous. As a result of this exercise, entire available spectrum in WB can be put to auction. Therefore, the Authority is of the view that DoT may carry out harmonisation exercise so that entire available spectrum can be put to auction.

2.6 Further, as per the information submitted by M/s BSNL, it has closed its CDMA services in 6 LSAs viz. Bihar, Haryana, Punjab, HP, UP (W) and Kolkata. In all these LSAs, M/s BSNL is holding 1.25 MHz administrative assigned spectrum in 800 MHz band, which was assigned for provision of CDMA services. Since, M/s BSNL has closed down CDMA services in these LSAs, the Authority is of the view that such spectrum held by it may be taken back and put to auction in the forthcoming auction.

900 MHz Band (890-915 MHz/935-960 MHz)

2.7 In the auction held in October 2016, a total of 9.4 MHz spectrum was put to auction in the 900 MHz band in 4 LSAs viz. Bihar, Gujarat, UP(W) and UP(E). No bid was received for the spectrum in this band. Therefore, entire spectrum (9.4 MHz) is available for auction.

2.8 M/s Aircel, whose service licence in Tamil Nadu (incl. Chennai), is expiring in December 2018, is holding administratively assigned spectrum in 900 MHz and 1800 MHz bands as given below:

Table 2.2

Spectrum becoming available due to expiry of licence of M/s Aircel

Service Area	**900 MHz band**	**1800 MHz band**
Tamil Nadu excluding Chennai	7.8 MHz	2.0 MHz
Chennai Only	6.2 MHz	2.4 MHz

2.9 Due to expiry of licence of M/s Aircel in December 2018, 7.8 MHz spectrum in Tamil Nadu (excluding Chennai) and 6.2 MHz spectrum in Chennai in 900 MHz band will be released. Therefore, 6.2 MHz in 900 MHz band can be put to auction in entire Tamil Nadu service area. As informed by DoT, spectrum in 900 MHz band that may be put to auction in the forthcoming auction is given below:

Table 2.3
Spectrum availability in 900 MHz Band

Sl. No.	Service Area	Total spectrum available for auction
1	Bihar	4.6 MHz
2	Gujarat	3.0 MHz
3	Tamil Nadu	6.2 MHz
4	UP (East)	0.6 MHz
5	UP (West)	1.2 MHz

2.10 In addition, 1.8 MHz spectrum in 900 band is available in part of the Tamil Nadu service area (excluding Chennai) and the same can also be put to auction following the principle of charging partial spectrum prescribed in earlier Notice Inviting Applications (NIAs)[1].

2.11 Further, through its letter dated 23rd July 2018, DoT has informed that the exercise of harmonization of spectrum in 900 MHz band is going on, due to which additional spectrum in the range of 0.8 MHz to 4.6 MHz is likely to be made available for auction in certain LSAs after vacation of Defence operations from this band.

[1] **Notice Inviting Applications – August 2016:** For the LSAs, where the spectrum is not available in some of the districts, while the bids will be sought for spectrum in entire LSA, the bid amount will be collected only for the spectrum available and the balance collected as and when spectrum is made available in each District, the amount being pro-rated to the population of that district(s) (as of census of 2011) and the balance period (of the 20 years). Bid amount as mentioned above will be collected subject to the condition that the amount to be collected in future at the time of providing balance spectrum would be the balance prorated bid amount indexed on the SBI PLR prevalent for the period between finalisation of bid price and actual assignment made.

1800 MHz (1710-1785 MHz/1805-1880 MHz)

2.12 In the auction held in October 2016, a total of 221.6 MHz spectrum was put to auction in the 1800 MHz band in all the LSAs, except Tamil Nadu. Out of this, 174.8 MHz spectrum was sold in 19 LSAs. The remaining unsold 46.8 MHz spectrum in 13 LSAs is available for the forthcoming auction. The details are given below:

Table 2.4

Spectrum that remained unsold in 1800 MHz Band

LSA	Total spectrum put in Oct 2016 auction	Spectrum sold	Spectrum that remained unsold
	A	B	C=A-B
	MHz	MHz	MHz
DEL	12.8	2	10.8
MUM	5	5	0
KOL	4	4	0
MH	13.4	12	1.4
GUJ	13	11.4	1.6
AP	4.4	2.4	2
KTK	4.2	0	4.2
TN	0	0	0
KL	2	0.6	1.4
PB	15.4	11	4.4
HR	7.4	7.4	0
UP (W)	14.6	14.6	0
UP (E)	5.4	5.4	0
RAJ	11	11	0
MP	4.6	4.6	0
WB	18.4	17.6	0.8
HP	11.4	5.6	5.8
BH	12.2	11.8	0.4
OR	1.4	0	1.4
AS	19.8	16.8	3
NE	9.2	9.2	0
J&K	32	22.4	9.6
Total	**221.6**	**174.8**	**46.8**

2.13 As can be seen from Table 2.2, due to expiry of licence of M/s Aircel in December 2018, 2.0 MHz spectrum in Tamil Nadu (excluding

Chennai) and 2.4 MHz spectrum in Chennai in 1800 MHz band will be available. As per an agreement reached with Ministry of Defence, 55 MHz spectrum shall be assigned for commercial mobile service in each LSA. Total spectrum assigned for commercial telecom services in Tamil Nadu in the 1800 MHz band has exceeded by about 4.4 MHz beyond 55 MHz. Therefore, DoT vide its letter dated 19th April 2017 informed that spectrum which will be available due to expiry of licence of M/s Aircel in the 1800 MHz band in Tamil Nadu LSA will not be proposed to put in the forthcoming auction. This spectrum will be given to Defence.

2.14 Further, some additional spectrum became available due to (i) surrender of license by M/s Aircel/Dishnet in 6 LSAs viz. Gujarat, Haryana, Madhya Pradesh, Himachal Pradesh, UP(West) and Maharashtra, and (ii) Closure of GSM services by M/s RCom. The details of the spectrum available for auction, as provided by DoT vide its letter dated 23rd July 2018, are given below:

Table 2.5

Spectrum availability in 1800 MHz Band

LSA	Total spectrum available for auction (MHz)
DEL	15.2
MUM	4.2
KOL	6.2
MH	10.2
GUJ	6
AP	6.4
KTK	8.6
TN	2.2
KL	5.8
PB	8.8
HR	8.8
UP (W)	8.8
UP (E)	4.4

RAJ	4.4
MP	4.4
WB	0.8
HP	10.2
BH	0.4
OR	1.4
AS	3
NE	0
J&K	14
Total	**134.2**

2100 MHz Band (1920-1980 MHz/2110-2170 MHz)

2.15 In the auction held in October 2016, a total of 360 MHz spectrum was put to auction in the 2100 MHz band in all the 22 LSAs. Out of which, 85 MHz spectrum was sold in 12 LSAs. The remaining unsold 275 MHz spectrum in 21 LSAs is available for the forthcoming auction as given below:

Table 2.6

Spectrum availability in 2100 MHz Band

LSA	Total spectrum put in Oct 2016 auction	Spectrum sold	Spectrum that remained unsold	Total spectrum available for auction
	A	B	C=A-B	D=C
	MHz	MHz	MHz	MHz
DEL	20	5	15	15
MUM	20	5	15	15
KOL	15	0	15	15
MH	15	5	10	10
GUJ	15	0	15	15
AP	20	0	20	20
KTK	15	0	15	15
TN	15	10	5	5
KL	15	5	10	10
PB	15	5	10	10
HR	15	5	10	10
UP (W)	15	0	15	15
UP (E)	15	10	5	5

RAJ	15	15	0	0
MP	15	0	15	15
WB	15	0	15	15
HP	20	0	20	20
BH	20	10	10	10
OR	20	5	15	15
AS	15	0	15	15
NE	15	0	15	15
J&K	15	5	10	10
Total	**360**	**85**	**275**	**275**

2300 MHz Band (2300- 2400 MHz)

2.16 In the auction held in October 2016, a total of 320 MHz spectrum was put to auction in the 2300 MHz band in 16 LSAs. Entire spectrum was sold. Earlier, through 2010 auctions, 40 MHz was assigned in each of the 22 LSAs. Therefore, out of the total 100 MHz, 60 MHz[2] in 16 LSAs and 40 MHz in 6 LSAs have been assigned to the different TSPs. Several point-to-point links of PSUs and State Electricity Boards are working in the remaining portion of spectrum in this band. It has been noted that as per an agreement with Ministry of Defence, 20 MHz in the 2300 MHz band is to be assigned to the Defence. Remaining 20 MHz in the 16 LSAs and 40 MHz in the 6 LSAs can be made available for commercial telecom services subject to the relocation of existing users to some other bands. DoT, vide its letter dated 7th September 2017, informed that the spectrum which may be available after refarming is scattered, and the same would be made contiguous after harmonisation of the band. The details of the spectrum that will be made available for telecom services is given below:

[2] 40 MHz spectrum in each of the 22 LSAs was assigned through the 2010 auction. In 2016 auction, 20 MHz spectrum was assigned in 16 LSAs.

Table 2.7

Spectrum availability in 2300 MHz band

LSA	Total spectrum available
	MHz
DEL	20
MUM	20
KOL	20
MH	20
GUJ	20
AP	20
KTK	20
TN	20
KL	20
PB	40
HR	40
UP (W)	40
UP (E)	40
RAJ	40
MP	20
WB	20
HP	20
BH	20
OR	20
AS	20
NE	20
J&K	40
Total	**560**

2.17 The Authority is of the view that DoT should carry out refarming and harmonization exercise in the 2300 MHz band at the earliest and ensure that entire spectrum that is available for commercial use is put to auction so as to avoid a situation where precious spectrum in this band remains unutilized resulting in revenue loss to the Government.

2500 MHz (2500-2690 MHz)

2.18 In the auction held in October 2016, a total of 600 MHz spectrum (40 MHz in 8 LSAs and 20 MHz in 14 LSAs) was put to auction in the 2500 MHz band. Out of which, 370 MHz spectrum was sold in 20 LSAs. The remaining unsold 230 MHz spectrum in 12 LSAs is available for the forthcoming auction as given below:

Table 2.8

Spectrum availability in 2500 MHz Band

LSA	Total spectrum put in Oct 2016 auction	Spectrum sold	Spectrum that remained unsold	Total spectrum available for auction
	A	B	C=A-B	D=C
	MHz	MHz	MHz	MHz
DEL	40	20	20	20
MUM	40	20	20	20
KOL	40	20	20	20
MH	40	30	10	10
GUJ	40	30	10	10
AP	40	10	30	30
KTK	40	0	40	40
TN	40	0	40	40
KL	20	20	0	0
PB	20	10	10	10
HR	20	20	0	0
UP (W)	20	20	0	0
UP (E)	20	20	0	0
RAJ	20	20	0	0
MP	20	20	0	0
WB	20	20	0	0
HP	20	10	10	10
BH	20	10	10	10
OR	20	20	0	0
AS	20	20	0	0
NE	20	20	0	0
J&K	20	10	10	10
Total	**600**	**370**	**230**	**230**

3300-3400 MHz Band

2.19 DoT through its reference dated 19th April, 2017 informed that spectrum in 3300-3400 MHz band has been allotted to various Internet Service Providers (ISPs) in various districts of a service area. The assignments are being renewed on annual basis. In its reference, DoT has mentioned that the entire 3300-3400 MHz band can be made available for telecom services subject to relocation/shifting of existing operations of the ISPs in 3300-3400 MHz band to other bands. DoT also mentioned that a case for harmonisation/vacation of this band is being initiated and it is expected that entire band will be made available for telecom services by the end of 2017. Accordingly, DoT has proposed to include 100 MHz in all the 22 LSAs in the 3300-3400 MHz band for the forthcoming auction for access services.

3400-3600 MHz Band

2.20 DoT through its reference dated 19th April, 2017 informed that out of the 200 MHz available in this band, 25 MHz spectrum (3400 MHz - 3425 MHz) is identified for ISRO's use in Indian Regional Navigation Satellite System (IRNSS) and the remaining 175 MHz (3425 MHz - 3600 MHz) spectrum is available for access services. It is understood that ISRO would be using this 25 MHz spectrum at few locations only. Reserving the entire 25 MHz on Pan India basis would lead to wastage of this precious spectrum. Therefore, the Authority is of the view that barring the specific locations or districts where ISRO is using this spectrum, the entire 200 MHz should be made available for access services and should be put in the forthcoming auction.

B. ECO SYSTEM OF MOBILE BROADBAND DEVICES IN VARIOUS SPECTRUM BANDS

2.21 LTE is specified by 3GPP as a single global standard for paired and unpaired spectrum users. It is the fastest developing mobile system

technology ever. As per the report on 'Status of the LTE Ecosystem' released in the month of May 2018, there are 675 LTE/LTE-Advanced commercial networks. There are 11,489 LTE user devices including frequency and operator variants from 637 suppliers. Around 66% of total devices are mobile phones. Most devices operate in FDD mode while the number of terminals that support LTE TDD (TD-LTE) continues to grow with around 4,770 devices (41.5% of all LTE devices). Following Tables gives the frequency band-wise number of LTE supported devices[3].

Table 2.9

LTE supported user devices as of May 2018

LTE bands in India	3GPP band no.	Frequencies	Number of LTE supported user devices
LTE FDD			
APT700 MHz	Band 28	703-748/758-803 MHz	1211 devices
850 MHz	Band 5	824-844/869-889 MHz	3876 devices
900 MHz	Band 8	890-915/935-960 MHz	3487 devices
1800 MHz	Band 3	1710-1784/1805-1880 MHz	7731 devices
2100 MHz	Band 1	1920-1980/2110-2170 MHz	6282 devices
LTE TDD			
2300 MHz	Band 40	2300-2400 MHz	3779 devices
2600 MHz	Band 41	2500-2690 MHz	2906 devices
3500 MHz	Band 42	3400-3600 MHz	202 devices

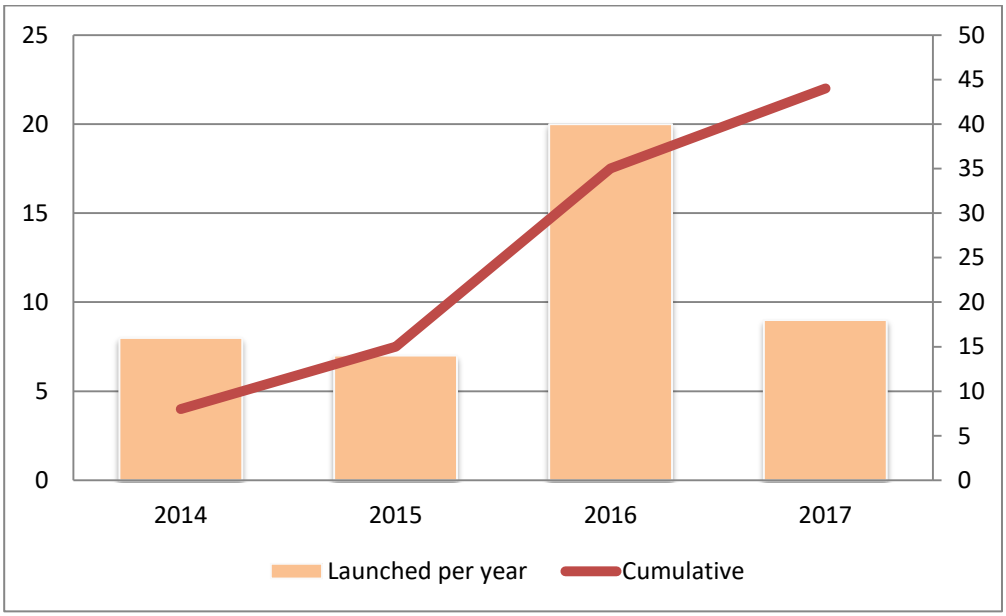
2.22 **Device Eco-system in APT700 MHz band**: According to GSA report[4] "GSA Snapshot: LTE in APT700 Spectrum Global Status" published in February 2018, 44 operators have launched commercial services using APT700 band 28 or in compatible European bands (CEPT 700)

[3] GSA's (Global Mobile Suppliers Association) report titled "Status of the LTE Ecosystem" published in May 2018

[4] https://gsacom.com/paper/gsa-snapshot-apt700-status-feb-2018/

(Refer Chart 2.1). Over 50 countries and territories have allocated, or committed to APT700 FDD (band 28), or compatible European bands, for LTE system deployments. Many countries including Argentina, Australia, Bhutan, Brazil, Chile, Ecuador, Fiji, Guyana, Japan, Maldives, Mexico, Mongolia, New Zealand, Nigeria, Panama, Papua New Guinea, Peru, Philippines, Samoa, Singapore, South Korea, Suriname, Taiwan, Tokelau Uruguay, and Vanuatu have licensed APT700 band 28 to the mobile operators in their country. At the time of last spectrum auction held in October 2016, there were about 469 devices which supported APT 700 band 28, which has grown to 1211 in May 2018.

Chart 2.1: Growth of commercial networks using APT700 band 28 or compatible European Band



2.23 **Device Eco-system in 3300-3400 and 3400-3600 MHz Bands**: Internationally, there appears to be growing interest in use of the 3300–3600 MHz band for Mobile Broadband (MBB). The 3300-3400 MHz portion of spectrum has already been identified for IMT[5] in 45 countries in regions such as Africa (33 countries) in Region 1, Latin

[5] *http://www.acma.gov.au/~/media/Spectrum Transformation and Government/Issue for comment/IFC 22 2015/Mobile broadband work program February 2016 update docx.docx*

America (6 countries) in Region 2, and the Asia Pacific Africa (6 countries) in Region 3. Being a recently identified band for IMT, there is no band plan for 3300-3400 MHz, APT Wireless Group (AWG) has started working on harmonized frequency arrangements for recently identified IMT bands including 3300-3400 MHz band.

2.24 As far as 3400–3600 MHz frequency range is concerned, it has been identified for the IMT in all of Region 1 and Region 2. In Region 3, 11 countries including India (Australia, Bangladesh, China, India, Iran, Korea, Japan, New Zealand, Pakistan, Philippines and Singapore) have allocated some or the entire 3400 to 3600 MHz band to IMT. 3GPP has already identified the 3400–3600 MHz frequency ranges as LTE band. There are specifications for both TDD and FDD in this band. However, there is strong momentum for TDD systems in this band. Band B42 represents the TDD arrangement in the frequency range 3400-3600 MHz band.

2.25 Altogether, there are 105 LTE-TDD (TD-LTE) systems in different spectrum bands commercially launched in 57 countries. Band B42 caters to 29 of them. Refer Table below.

Table 2.10: Commercially launched LTE-TDD networks

3GPP band no.	Frequencies	Number of Commercial LTE-TDD Networks
Band 38	2570-2620 MHz	21
Band 39	1880-1920 MHz	01
Band 40	2300-2400 MHz	38
Band 41	2496-2690 MHz	23
Band 42	3400-3600 MHz	29
Band 43	3600-3800 MHz	05

Source: GSA report on 'GSA Snapshot: LTE-TDD (TD-LTE) Global Status' of February 2018

2.26 **IMT 2020 (5G) Systems**: Spectrum in frequency range 3300-4200 MHz is likely to emerge as primary band for early 5G introduction. Therefore, a number of countries in different regions are taking

action towards refarming 200-400 MHz of contiguous bandwidth in the 3300-4200 MHz frequency range for 5G. This will be the largest contiguous bandwidth for IMT below 6 GHz.

2.27 There have been 5G focused activities in some major telecom markets. Parts of the 3300-4200 MHz range is being considered for early trials in a number of countries/regions in the world. **China's** Ministry of Industry and Information Technology (MIIT) issued the frequency plan for the 3300–3400 MHz, 3400–3600 MHz, and 4800–5000 MHz bands for IMT-2020 (5G). It stated that the 3300–3400 MHz band would be for indoor use for 5G services. At the same time, a series of 5G verification tests is being implemented by China's IMT 2020 (5G) promotion group. The first two tests have been completed. The third set of verification tests will continue until September 2018. Many of the trials in these tests used C-band spectrum (largely around 3500 MHz), with the occasional test in the 26 GHz band. In **Japan**, the Ministry of Internal Affairs and Communications (MIC) has declared that the official 5G bands in the archipelago are 3700 MHz, 4500 MHz and 28 GHz. Among the operators in the country there has been a broad mix of different spectrum used for trials, including 3500 MHz, 4500 MHz, 28 GHz, and 70 GHz.

2.28 In **Europe**, considerable 5G preparatory work has focused on the 3400–3800 MHz spectrum range. Many other spectrum bands are also being investigated for 5G including 700 MHz, 1800 MHz, 2600 MHz, 4650–4850 MHz, 15 GHz, 24.25–29.5 GHz, as well as 70 GHz. **Australia** has focused initially on the 3400 MHz band. The Australian Communications and Media Authority (ACMA) has also made public its plans to auction the 3600 MHz band for 5G use in Oct–Dec 2018 and mmWave band in Jul–Sep 2019. An auction of 1500 MHz spectrum is also expected to take place in Oct–Dec 2019. The **US** decided in July 2016 to use mmWave spectrum for 5G

services in the 28 GHz, 37 GHz, 39 GHz bands for licensed services and 64–71 GHz for unlicensed services.

C. TIMING OF AUCTION

2.29 As mentioned earlier, the last auction for access spectrum was held in October 2016 wherein around 60% spectrum remained unsold. The spectrum acquired by various TSPs in the said auction is yet to be deployed fully. Moreover, the Telecom Industry has been undergoing consolidation phase as some of the TSPs have filed for merger of their companies/licences while a few licensees traded their entire spectrum holding and closed their services. Due to competition, concerns have been expressed about the financial health of the sector, its revenue growth and the capability of the companies to meet their contractual commitments etc.

2.30 In this background, the stakeholders were asked to give their opinion on when the next access spectrum auction should be held. The stakeholders were also asked to comment that, in case the auctions are held now, should the entire spectrum be put to auction or should it be done in phased manner i.e. auction for some of the bands be held now and for other bands later based on development of eco system etc.

2.31 Most stakeholders were of the view that at present the industry is going through a phase of substantial mergers and acquisitions and it is important to allow the market to settle down when the industry is going through a massive phase of consolidation. Mergers and harmonisation will lead to efficiencies in terms of use of existing spectrum and then the companies would be in a better position to look at additional spectrum needs. Some of these stakeholders submitted that under these circumstances, any untimely auction of spectrum may accrue revenue to the Government, but the

commercial exploitation of such scarce resource for the larger interest of the society may not be as expected.

2.32 Some stakeholders were of the view that the spectrum auction should be held in 2019 when 5G technology is likely to be available for commercial launch in India. On the other hand, one stakeholder suggested that for explosion of 4G services and advent of 5G, more spectrum is required and auction of spectrum should not be delayed.

2.33 Most stakeholders were of the view that, whenever auctions are held, entire available spectrum should be put to auction. A few stakeholders submitted that the ecosystem in 700 MHz and 3400-3600 MHz has still not developed. So even if auction is to take place, these bands should not be auctioned before 2020. One of these stakeholders has added that there is no need to auction 3300 to 3600 MHz when 700 MHz band is still unutilized.

Analysis

2.34 World-over, the Telecommunications has been recognized as an important tool for socio-economic development for a nation. It is one of the prime support services needed for rapid growth and modernization of various sectors of the economy. Spectrum is one of the most important and crucial ingredients for wireless communication services. With the increasing demand for data services and uptake of data hungry applications, the need for spectrum has been ever increasing. Availability of sufficient spectrum is crucial in achieving the objectives of 'Digital India'. In the last one year, with 4G taking off in real sense, the data usage has increased exponentially in India. Total mobile data usage has increased from 462 petabytes in quarter ending September-2016 to 7879 petabytes in quarter ending March-2018, thereby showing an increase of more than 17 folds. With the exponential growth in data usage, India has become one of the countries with highest mobile data usage. To keep

pace with the increasing demand of data services, it is essential that spectrum is auctioned at regular intervals.

2.35 In the recent times, Indian telecom sector has witnessed various merger & acquisition proposals and there is definite amount of visibility as far as consolidation of industry is concerned. Therefore, it would not be entirely correct to say that industry is not in a position to assess its spectrum requirements.

2.36 As discussed earlier, device eco system in the 700 MHz band is developing very fast. Some of the spectrum bands viz. 3300-3400 and 3400-3600 are part of frequency range 3300-4200 MHz, which is likely to emerge as primary band for early IMT-2020 (5G) introduction. Machine-to-Machine (M2M) communication service is already beginning to make its mark in India. The completion of the first 5G NR standard for a NSA (non Stand Alone) solution in December 2017 and for SA (Stand Alone) standard in June 2018 has set the stage for the global mobile industry to start full-scale development of 5G NR for large-scale trials and commercial deployments as early as in 2019[6].

2.37 In addition to the above factors, it would take some more time to actually conduct the auction. Therefore, it may not be prudent to either delay the auction or hold back the spectrum.

2.38 In view of the forgoing discussion, **the Authority recommends that**

(a) Entire available spectrum should be put to auction in the forthcoming auction.

b) In the era of administrative assignment of spectrum, the spectrum was unliberalized i.e. not technology neutral and was assigned either to provide GSM services or CDMA

[6] https://www.ericsson.com/en/news/2017/12/global-mobile-industry-ready-for-full-scale-development-of-5g-nr

services. In case of closure of GSM or CDMA services, a TSP cannot be allowed to hold the administratively assigned spectrum for which it has not paid the market determined price. Any such spectrum lying with TSPs should be taken back and put to auction in the forthcoming auction.

c) DoT should carry out harmonization exercise in West Bengal (WB) LSA in 800 MHz band so that entire available spectrum can be made contiguous and put to auction in the forthcoming auction.

d) DoT should carry out refarming and harmonization exercise in the 2300 MHz band at the earliest and ensure that entire spectrum that is available for commercial use is put to auction so as to avoid a situation where precious spectrum in this band remains unutilized resulting in revenue loss to the Government.

e) Barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum, the entire spectrum from 3300 MHz to 3600 MHz should be made available for access services and should be included in the forthcoming auction.

D. BLOCK SIZE

a) Existing bands i.e. 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands

2.39 Spectrum in the 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands was put to auction in the Oct 2016. The block size and the minimum quantity of spectrum to be bid for by Existing Licensee/ New Entrant, in respect of these bands, as per the NIA, is given in Table below:

Table 2.11

Block size and minimum quantity for bidding as per NIA of September 2016

Spectrum Band	Block Size (MHz)	Minimum amount of spectrum that a bidder is required to bid for	
		Existing licensees (MHz)	New Entrants (MHz)
700 MHz	5 (paired)	NA	5
800 MHz	1.25 (Paired)	1.25	5/ 3.75 (if only 3.75 MHz spectrum was available)/2.5 (if only 2.5 MHz spectrum was available)
900 MHz	0.20 (paired)	0.6	5
1800 MHz	0.20 (paired)	0.6	5 MHz, if at least one chunk of contiguous 5 MHz is available; else, 0.6 MHz
2100 MHz	5 (paired)	5	5
2300 MHz	10 (unpaired)	10	10
2500 MHz	10 (unpaired)	10	10

2.40 In the Consultation Paper, stakeholders were asked whether the block sizes and minimum quantity for bidding in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands, be kept same as in the last auction. In response, most stakeholders submitted that there is no need to make any changes in the block sizes and the minimum quantity for bidding as per the provisions contained in the last NIA should be retained.

2.41 One stakeholder submitted that some spectrum in 900 MHz band is sparingly assigned to some govt. users for establishing point to point links, which can be migrated. It will result in additional availability of spectrum in the range of 2.4 – 6 MHz. If the requirement of minimum bidding is retained as 5 MHz in 900 MHz band for new entrants; they will not be able to participate in a number of LSAs. Therefore, according to the stakeholder, requirement for new entrant in 900 band may be revised as 5 MHz or entire spectrum if total available spectrum is less than 5 MHz. Another stakeholder submitted that keeping in view the exponentially growing demand for data services &

consolidations taking place in Indian Telecom sector, minimum block size of 20 MHz is recommended for auction of spectrum in any band.

Analysis

2.42 It is fact that minimum 5 MHz (paired) contiguous spectrum block is desired for the deployment of latest technologies. Therefore, wherever practicable, spectrum is now typically awarded in blocks of minimum 5 MHz (paired) in the case of Frequency Division Duplex (FDD). However, if the spectrum available is less than 5 MHz, it cannot be kept idle.

2.43 It is only the 800 MHz, 900 MHz and 1800 MHz bands, wherein the available spectrum is less than 5 MHz in some LSAs. In the past NIAs, suitable provisions have been incorporated in the 800 and 1800 MHz bands where bidders (new entrant as well as incumbents) were permitted to bid for less than 5 MHz in such cases. However, no such provisions were made in the NIA for 900 MHz band. This is despite the fact that the Authority, in its earlier recommendations on 'Valuation and Reserve Price of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz Bands' dated 27th January 2016, had recommended that, in case of 900 MHz band, the new entrant should be allowed to bid for 5 MHz if at least one chunk of contiguous 5 MHz is available, else the minimum block size should be kept as 0.6 MHz. However, in the auction held in October 2016, a new entrant was required to bid for minimum 5 MHz in the 900 MHz band; which practically bars the new entrant from bidding in the LSAs where spectrum available itself is less than 5 MHz in the 900 MHz band.

2.44 Spectrum assigned through auction is liberalised i.e. it is technology agnostic. Moreover, carrier aggregation technique allows aggregation of spectrum carriers in same as well as in different bands. Therefore,

a bidder, including the new entrant, should be given option to decide whether it wants to bid for smaller chunks of spectrum or not.

2.45 In view of the above, **the Authority recommends that in case of 900 MHz band, the new entrant should be allowed to bid for 5 MHz if at least one chunk of contiguous 5 MHz is available, else the minimum block size should be kept as 0.6 MHz. Barring this, principles based on which all the provisions of block size and minimum quantity for bidding were specified in the NIA of September 2016, should be retained. It leads to the following table:**

Table 2.12

Block size and minimum spectrum for bidding

Spectrum Band	Block Size (MHz)	Minimum amount of spectrum that a bidder is required to bid for	
		Existing licensees (MHz)	New Entrants (MHz)
700 MHz	5 (paired)	NA	5
800 MHz	1.25 (Paired)	1.25	5/ 3.75 (if only 3.75 MHz spectrum is available)/2.5 (if only 2.5 MHz spectrum is available)/ 1.25 (if only 1.25 MHz spectrum is available)
900 MHz	0.20 (paired)	0.6	5 MHz, if at least one chunk of contiguous 5 MHz is available; else, 0.6 MHz
1800 MHz	0.20 (paired)	0.6	5 MHz, if at least one chunk of contiguous 5 MHz is available; else, 0.6 MHz
2100 MHz	5 (paired)	5	5
2300 MHz	10 (unpaired)	10	10
2500 MHz	10 (unpaired)	10	10

b) 3300-3400 MHz and 3400-3600 MHz bands

2.46 In the Consultation paper, the stakeholders were requested to give their opinion on the optimal block sizes and minimum quantity for bidding in (a) 3300-3400 MHz and (b) 3400-3600 MHz bands keeping in mind both the possibilities i.e. frequency arrangement could be FDD or TDD. In response, a number of stakeholders suggested that

considering the global trend, TDD mode should be adopted in the frequency bands 3300-3400 MHz and 3400-3600 MHz bands.

2.47 One stakeholder suggested that to offer ultra mobile broadband services (uMBB), 5G would essentially require large contiguous spectrum blocks per operator. Therefore, a minimum block size of 10 MHz with a minimum average holding of 50 MHz per operator for 5G/NR deployments is required. Another stakeholder proposed that considering the result of a few international auctions in this band and momentum towards TDD systems, there should be a 10 MHz block size, with an assurance on contiguity of the spectrum in case a bidder opts to acquire multiple blocks.

2.48 A few stakeholders submitted that the block size of 20 MHz seems optimal as the minimum quantity for bidding in 3.3 GHz to 3.6 GHz. One stakeholder was of the view that block size of 5 MHz (Paired) or 10 MHz (unpaired) should be kept with the condition that the bidders should be mandated to bid for atleast 10 MHz (Paired) or 20 MHz (Unpaired).

2.49 A few stakeholders submitted that channel bandwidth for 5G technology is being planned in increment of 10 MHz upto 60 MHz & 20 MHz beyond 60 MHz. A block size of 5 MHz has a risk of fragmenting the spectrum and making it non-efficient for usage. Hence, according to these stakeholders, 10 MHz of block size is recommended for the auction. Further, 20 MHz spectrum (i.e. 2 blocks) should be defined as minimum amount of spectrum for bidding. Few stakeholders were of the view that taking into account the trends of allocating at least 100 MHz spectrum per operator in many other countries preparing for 5G development, a block size or block sizes between 50 to 100 MHz for the auction of 3300-3400 MHz and 3400-3600 MHz frequency bands should be chosen, in order to accommodate 3 to 4 operators in these two bands. Another

stakeholder suggested that blocks in 5 MHz size (TDD) should be offered with the condition that bidders will have to bid for minimum 2 number of such blocks.

Analysis

2.50 In the past auctions, there is no instance of setting block sizes for 3300-3400 MHz and 3400-3600 MHz bands as these bands shall be put to auction for the very first time. A few auctions have taken place in other countries in this frequency range which are discussed below.

Ireland

2.51 In May 2017, Irish regulator ComReg conducted auction for the award of 350 MHz of spectrum in the 3.6 GHz (3400-3800 MHz) band. These spectrum rights were awarded on a regional basis. Entire country was divided into 9 regions for this purpose. The spectrum right was made available in each Region as set out in the following Table:

Table: 2.13: Details of Spectrum put to Auction

Band	Frequency Range (MHz)	Spectrum Available	Blocks of Spectrum put to auction
3.6 GHz	3410-3435	25 MHz	One block of 25 MHz
	3475-3800	325 MHz	65 blocks of 5 MHz

2.52 The spectrum was divided into two Lot types, A-Lots and B-Lots. The A-Lot consisted of 25 MHz of spectrum and was positioned below State Services from 3410 MHz to 3435 MHz. The B-Lots consist of sixty-five 5 MHz Lots positioned above State Services from 3475 – 3800 MHz. The auction design allowed both regional and national operators to acquire spectrum rights of use for large contiguous blocks of TDD spectrum in multiples of 5 MHz TDD configuration.

2.53 Imagine Communications Ireland Ltd (Imagine), currently the largest Wireless Internet Service Provider (WISP) obtained spectrum rights of use for 60 MHz in each of the four rural regions. Airspan Spectrum Holdings Ltd (Airspan), a new entrant- obtained spectrum rights of use for 25 MHz in the rural regions and 60 MHz in the cities; Vodafone Ireland Ltd, a mobile network operator obtained 85 MHz in rural regions and 105 MHz in the cities; Three Ireland Hutchison Ltd, a mobile network operator, obtained 100 MHz nationally; Meteor Mobile Communications Ltd, a mobile network operator obtained 80 MHz in the rural regions and 85 MHz in the cities.

Czech Republic

2.54 In June 2017, the regulator, the Czech Telecommunication Office (Cesky telekomunikacni urad, CTU), auctioned 200 MHz of spectrum in the 3.7 GHz band (3600MHz-3800MHz). Entire spectrum was divided in five 40 MHz blocks. Established operators were restricted to acquiring a single 40 MHz block, while new players were permitted to purchase a total of 80 MHz. Existing operators O2 Czech Republic and Vodafone Czech Republic each gained a block of 40 MHz in the auction by the Czech Telecommunication Office, as did new entrant PODA. The other new entrant, Nordic Telecom 5G, acquired 80 MHz of spectrum.

UK

2.55 OFCOM has recently (in April 2018) auctioned spectrum in the 2300 MHz and 3400 MHz spectrum bands. A total of 190 MHz worth of spectrum comprising of 40 MHz in the 2300 MHz band (2350 MHz-2390 MHz) and 150 MHz in the 3400 MHz band (3410 MHz-3480 MHz, 3500 MHz-3580 MHz) was put to auction[7]. 2300 MHz spectrum

[7] https://www.ofcom.org.uk/about-ofcom/latest/media/media-releases/2018/results-auction-mobile-airwaves

was auctioned to help improve 4G capacity for today's mobile users; and 3400 MHz has been earmarked for 5G, the next generation of mobile technology. Block size was kept as 10 MHz in the 2300 MHz band and 5 MHz in the 3400 MHz band on a Time Division Duplex (TDD) basis. To protect bidders against the risk of acquiring unwanted smaller amounts of spectrum, OFCOM allowed them to specify a minimum requirement of up to 20 MHz (i.e. four 5 MHz lots) in the Simultaneous Multiple Round Auction (SMRA) auction format with a condition that a bidder, who ended the auction as the standing high bidder on fewer lots than what had specified in its minimum requirement for a given category, would not be assigned any lots in relation to these bids.

2.56 Five companies took part in the auction, which involved 34 'lots' (4 blocks of 10 MHz each in 2300 MHz band and 30 blocks of 5 MHz each in 3400 MHz band) of spectrum across the two bands. The total value of the principal stage was £1,355,744,000. Airspan Spectrum Holdings Limited could not win spectrum in either band. In 3.4 GHz band, EE Limited and Telefónica UK Limited won 40 MHz each, Hutchison 3G UK Limited won 20 MHz and Vodafone Limited won 50 MHz of spectrum. Telefónica UK Limited won all 40 MHz of available spectrum in 2.3 GHz band.

2.57 After completion of principal stage, Ofcom moved to the 'assignment' stage, which is the last bidding stage of the auction. This is a short process, which allows companies who have won spectrum in the principal stage to bid to determine where in the frequency bands their new spectrum will be located. As per the details published by Ofcom[8]. The details of the frequencies in respect of which the licences

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The 40 MHz of spectrum is held by UK Broadband[7] in the 3.4 GHz band (3480 to 3500 MHz and 3580 to 3600 MHz) which was awarded through an auction in 2003 for 15 years period.

[8] https://www.ofcom.org.uk/__data/assets/pdf_file/0018/112932/Regulation-111-Final-outcome-of-award.pdf

were granted and the details of licence fees paid are given in the table below:

Table: 2.14: Details of Spectrum Auction Results

Winning bidders to whom licence granted	**Frequencies (in MHz)**	**Total base price (Determined in the Principal Stage)**	**Additional prices (Determined in the Assignment Stage)**	**Licence fees paid**
(A)	**(B)**	**(C)**	**(D)**	**(E) = (C)+(D)**
EE Limited	3540 – 3580	£302,592,000	£1,002,000	£303,594,000
Hutchison 3G UK Limited	3460 – 3480	£151,296,000	£13,133,000	£164,429,000
Telefónica UK Limited	2350 – 2390	£205,896,000	N/A	£205,896,000
	3500 – 3540	£317,720,000	0	£317,720,000
Vodafone Limited	3410 – 3460	£378,240,000	0	£378,240,000

South Korea

2.58 South Korea's Ministry of Science and ICT (MSIT) recently (in June 2018) conducted 5G auction. It auctioned 280 MHz (3.42 to 3.7 GHz) of bandwidth in the 3.5 GHz band, and 2400 MHz (26.5 to 28.9 GHz) of bandwidth in the 28 GHz band. Frequencies were sold in 28 blocks of 10MHz for the 3.5GHz band and 24 blocks of 100MHz for the 28GHz band. For 3.5GHz band, which was considered to be more competitive, there was a cap of 100 MHz per bidder.

2.59 The auction was conducted in two phases, the first phase determined the quantity of frequencies each operator would get and the second determined the position of the spectrum. A minimum bid price of KRW2.65 trillion (USD2.5 billion) was set for the 3.5GHz frequencies, which has been offered for use for an initial ten-year period, while minimum bid price of KRW621.6 billion was set for a block in the 28 GHz band for five-year licence. The spectrum will be made available for use from December 2018.

2.60 All three incumbent mobile network operators (MNOs) won new frequencies. In 3.5 GHz band, two MNOs (STK and TK Corp) won 100 MHz spectrum each and one MNO (LG UPlus) won 80 MHz spectrum. In 28 GHz band, the three MNOs won 800 MHz each. The details are shown below:

Table: 2.15: Details of Spectrum Auction Results[9]

Mobile Network Operator	3.5 GHz Band		28 GHz Band	
	Spectrum won	**Winning price (for 10 years)**	**Spectrum won**	**Winning price (for 5 years)**
SKT	100 MHz (3.6-3.7 GHz)	KRW1.22 trillion (USD1.10 billion)	800 MHz (28.1-28.9 GHz)	KRW207.3 billion
KT Corp	100 MHz (3.5-3.6 GHz)	KRW968 billion	800 MHz (26.5-27.3 GHz)	KRW207.8 billion
LG UPlus	80 MHz (3.42-3.50 GHz)	KRW809.5 billion	800 MHz (27.3-28.1GHz)	KRW207.2 billion

Likely Uses of 3300-3400 and 3400-3600 MHz bands and Suitable Duplex Scheme

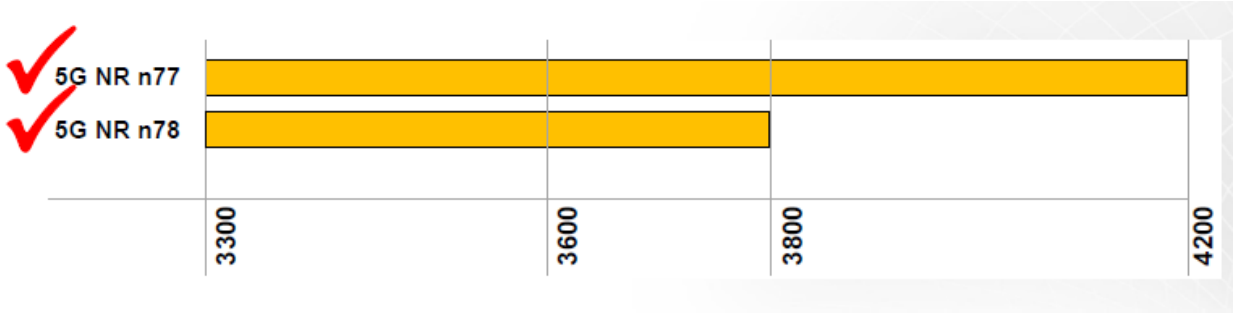
2.61 As discussed earlier, spectrum from 3400-3600 GHz is identified globally for IMT. Few countries are using this band for LTE. Over 200 LTE devices are also available in this band. As regards 3300-3400 MHz spectrum, the same has been identified for IMT by 45 countries across all the three regions. As 3300-3400 MHz band has been recently identified for IMT applications, LTE band plan has yet to be finalized. There is a huge possibility of these bands being used for new 5G mobile services because entire frequency range 3300-4200 MHz is likely to emerge as primary band for early 5G introduction.

2.62 Work has already started in 3GPP for the specification of the 5G-NR bands which will address the larger 3300-4200 MHz range. 3GPP has recently (in June 2018) frozen the Standalone 5G NR radio specifications. For the frequency range 3300-4200, 3GPP has identified two 5G NR band plans – n77 and n78. The Chart 2.2 given

[9] http://www.msit.go.kr/web/msipContents/contentsView.do?cateId=mssw311&artId=1386500

below shows the 3GPP channel arrangement of band n77 & n78. Further, the specifications by 3GPP support only TDD frequency arrangement for these bands. Even in LTE/LTE-Adv technology, the global trend is for the adoption of TDD configuration. Therefore, the Authority is of the view that 3300-3600 MHz should be auctioned as a single band and TDD based frequency arrangement should be adopted for this band.

Chart-2.2: 3GPP channel arrangements for 5G-NR



2.63 **Preferable Block Size:** As per the standards frozen so far by 3GPP [3GPP TS 38.104 V15.2.0 (2018-06)], for 5G NR bands n77(3300-4200 MHz) and n78(3300-3800 MHz), the supported channel bandwidth is 10 MHz, 15 MHz, 20 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 70 MHz, 80 MHz, 90 MHz, and 100 MHz. Though it is not yet clear what the optimum channel size for IMT or IMT 2020 will be, there are strong views that large contiguous blocks of spectrum may be desirable.

2.64 While some stakeholders opined that taking into account the trends of allocating at least 100 MHz spectrum per operator in many other countries preparing for 5G developments, block size should be between 50 to 100 MHz for auction of 3300-3600 MHz, most of the other stakeholders opined that the block size should be 10 MHz/20 MHz. However, there was a consensus view that that contiguity of spectrum should be ensured.

2.65 It is a fact that larger block size will be beneficial for improving mobile broadband experience and spectrum efficiency of the networks. On the other hand, smaller the block size provides greater flexibility but increases the chances of fragmentation. To provide flexibility and at the same time to attain greater efficiency and avoid the fragmentation of these bands, it would be desirable to keep block size as 20 MHz. As this band is crucial band for 5G deployment and possibility of new operators cannot be ruled out for provision of only 5G services using this spectrum band. Therefore, to ensure that no one single licensee is allowed to capture the complete band, the Authority is of the view that there should be a limit of 100 MHz per bidder. The block size of 20 MHz would give flexibility to the bidders and a maximum limit of 100 MHz per bidder would help in avoiding monopolization of this band. Since the TSPs are allowed to trade their partial or complete spectrum holding to another TSP, the limit of 100 MHz spectrum in 3300-3600 MHz band, shall apply for spectrum trading also.

2.66 Further, it is a well known fact that when more than one TDD networks operate in the same band and same geographic area, severe interference may happen if the networks are uncoordinated i.e. if some base stations (BSs) are transmitting while others are receiving. Synchronization is one of the techniques to avoid UL/DL interference without losing spectrum in guard bands. Synchronized Operation of TDD networks prevents simultaneous uplink and downlink. It can be implemented by means (a) Starting the frame in the same time and (b) Configuring compatible frame structures (length of the frame, and uplink/downlink ratio) so that all transmitter stop before any receiver starts.

2.67 Earlier, the issue of interference in the TDD networks was analysed by the Authority in 2016, when the unpaired spectrum in the 2300

MHz and 2500 MHz bands was put to auction. The Authority had recommended[10] that:

> *"…. the operation of adjacent LTE TDD networks in 2300/2500 MHz bands shall be time-synchronised and TSPs shall use the same frame structure with DL/ UL configuration of 3:1. Other technical aspects such as clock source, requirement to be fulfilled by Wi-MAX networks for co-existence at LSA border areas etc can be finalised by TEC. These provisions may be mandated in the NIA for auctioning of spectrum in this band. It can also be mandated that this provision can be reviewed later on as and when need arises. …… DoT should carry out carrier frequency re-assignment to make uniform carrier frequency assignment though out the country to the TSPs without any inter-operator guard band in the 2300 MHz band. It will result in additional spectrum for commercial use. The Authority also recommends if TSPs acquires additional block of 10MHz, it should be ensured that all its carriers are contiguous."*

2.68 Use of compatible frame structures is not always feasible. For instance, if two different technologies, say LTE & 5G, are deployed in the same band, compatible frame structures may not be possible. If the large contiguous blocks of spectrum are assigned to TSPs, they can manage the interference by mutual coordination and provisioning of guard bands. However, assignment of non-contiguous blocks would lead to fragmentation, necessitating increased provisioning of guard bands, which may lead to a situation that the spectrum assigned may not remain suitable for implementation of 5G technology. To reap the real advantage of 5G technology, it is important that the larger contiguous chunk of spectrum is available with the TSPs. Therefore, the Authority is of the view that while assigning spectrum blocks, contiguity of spectrum blocks should be ensured. In case a TSP is able to win more than two blocks of spectrum in the upcoming auctions, it should be allocated spectrum in contiguous blocks.

[10] Authority's recommendation on "Valuation and Reserve Price of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz Bands" dated 27th January 2016.

2.69 Further, possibility of interference may exist between far-off BTSs due to time-lag involved in the transmission of signal. In the 2300 MHz band, the interference issues have been reported in the neighboring LSAs if the overlapping frequency bands have been assigned to different TSPs in neighboring LSAs. This requires coordination amongst BTS sites which can be easily carried out if the TSP has been assigned same frequency spots across different LSAs.

2.70 In view of the above, **the Authority recommends that**

a) **3300-3600 MHz should be auctioned as a single band and TDD based frequency arrangement should be adopted for this band.**
b) **Spectrum in 3300-3600 MHz band should be put to auction in the block size of 20 MHz. To avoid monopolization of this band, there should be limit of 100 MHz per bidder. Since the TSPs are allowed to trade their partial or complete spectrum holding to another TSP, the limit of 100 MHz spectrum in 3300-3600 MHz band, shall also apply for spectrum trading.**
c) **In case a TSP acquires more than one block, the entire spectrum should be assigned to it in contiguous form.**
d) **In case a TSP acquires spectrum in 3300-3600 MHz band in more than one LSA, same frequency spots should be assigned to it in all those LSAs.**

E. Obligations to Roll-out Network

2.71 Given the fact that spectrum is a limited resource and should be used in an effective and efficient manner, roll-out obligations are mandated for the spectrum assigned to the TSPs.

a) Existing bands i.e. 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz bands

2.72 Roll-out obligations mandated in the NIA of September 2016 are discussed in the following paras.

Metro LSAs

2.73 In the NIA of September 2016, roll-out obligations in respect of Metro Service Areas for the spectrum in the 700 MHz, 800 MHz, 900 MHz and 1800 MHz bands mandated street-level coverage of 90% of the service area within one year from the effective date of licence or the date of assignment of spectrum won in the auction process, whichever is later[11] while the licensee who acquired the spectrum in the 2100 MHz, 2300 MHz or 2500 MHz bands, was required to provide the street-level coverage in at least 90% of the LSA within five years.

Non-Metro LSAs

2.74 In the NIA of September 2016, following roll-out obligations for non-metro LSAs were prescribed for the spectrum in the 700 MHz, 800 MHz, 900 MHz, 1800 MHz bands:

Table 2.16

Roll-Out Obligations for Spectrum in 700 MHz, 800 MHz, 900 MHz and 1800 MHz Bands

Phases of the Roll out	Roll Out Requirement	Time Period*
Phase 1	Coverage of 10% DHQs/ Towns	by the end of one year
Phase 2	Coverage of 50% DHQs/ Towns	by the end of three years
Phase 3	Coverage of 10% BHQs	by the end of three years
Phase 4	Coverage of additional 10% BHQs (Cumulative 20% BHQs).	by the end of four years
Phase 5	Coverage of additional 10% BHQs (Cumulative 30% BHQs).	by the end of five years

* From effective date of license or date of assignment of spectrum won in this auction process whichever is later.

[11] For this purpose, 900 & 1800MHz bands are treated as the same band.

2.75 For the spectrum in the 2100 MHz band, the following roll-out obligations for non- metro LSAs were prescribed:

Table 2.17

Roll-Out Obligations for Spectrum in 2100 MHz Band

Roll-out Phase	Roll Out Requirement	Time Period*
Phase 1	Coverage of 50% of DHQs in the LSA out of which 15% of DHQs/Towns should be in rural SDCA.	by the end of three years
Phase 2	Coverage of additional 10% DHQs	by the end of four years
Phase 3	Coverage of additional 10% DHQs	by the end of five years

* From effective date of license or date of assignment of spectrum won in this auction process whichever is later.

2.76 Roll-out obligations for non-metro LSAs for the spectrum in 2300 MHz and 2500 MHz band required that at least 50% of the rural SDCAs are covered within five years of the effective date[12] using the 2300 MHz /2500 MHz band spectrum.

2.77 As per the NIA provisions, the requirement of roll-out obligation would be treated as fulfilled once the required number of district headquarters or block headquarters are covered by use of any technology in any band held by a licensee. Therefore, the licensee is not required to fulfill these roll-out obligations separately in respect of each of these bands.

2.78 In the Consultation Paper, the stakeholders were asked to comment whether the roll-out conditions for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz stipulated in the last auctions held in October 2016 are appropriate.

[12] From the effective date of license or date of assignment of spectrum won in this auction process whichever is later.

2.79 Most of the stakeholders have responded that the existing roll-out conditions as stipulated in the NIA of September 2016 are appropriate. A few stakeholders have opined that roll-out obligations have no relevance in the era of auctioned spectrum. However, if the Government continues to favour mandatory roll-out obligations, the roll-out obligations prescribed under the NIA for 2016 auction may be continued without any change.

2.80 The Authority concurs with the view expressed by most stakeholders that the existing roll-out obligations are adequate for the existing bands. Therefore, **the Authority recommends that the roll-out obligations prescribed for the auctions held in 2016 for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz may be continued in the forthcoming auction.**

b) New bands i.e. 3300-3400 MHz and 3400-3600 MHz bands

2.81 In the Consultation paper, the stakeholders were asked to comment whether there should be any rollout obligations in 3300-3400 MHz and 3400-3600 MHz bands. The stakeholders were also asked to suggest the roll-out obligations, if they are of the view that roll-out obligations should be imposed on these bands.

2.82 Most stakeholders responded that unlike low frequency bands that are appropriate for providing wider coverage, the technical characteristics of 3300-3400 MHz and 3400-3600 MHz spectrum bands are not conducive for extending the geographical reach. These bands are likely to be deployed as capacity bands due to their limited coverage radii. These bands mostly will be utilized for 5G services. However, standardization/ specifications of 5G have not taken so far. Also, there is no certainty with respect to network and eco-system. Therefore, as per these stakeholders no roll-out obligations should be mandated for 3300-3400 MHz and 3400-3600 MHz bands.

2.83 Some stakeholders were of the view that there should be some roll out obligations across all the C-band spectrum bands while recognising that it will take longer for TSPs to roll out in the higher portions of this band. One stakeholder submitted that market for these bands would be well-matured only after a few years. Therefore, the roll-out obligations for these bands should be allowed a reasonable period for preparation. The stakeholder suggested that minimum roll-out obligations should be similar to 2300 MHz band with 5 year time period. Another stakeholder commented that there should be a very lenient roll-out obligations in these bands similar to other spectrum bands in last auction say 800/900/1800 i.e. Covering 50% DHQs and 30% BHQs in phases.

2.84 One stakeholder submitted that in case separate roll out obligations are mandated for these bands, adequate time, of at least 5 years should be given and the licensees should be allowed to meet rollout obligations using any technology in any band, as already permitted in 2016. It also stated that Test Schedule Test Procedure (TSTP) should be finalized and made available ahead of the auctions so that there is clarity and informed bidding.

2.85 A few stakeholders suggested that there is no need of any additional roll-out obligations to be imposed on some specific blocks of spectrum purchased through auction, if the TSP has already covered the rollout obligation in any spectrum band using any technology. One stakeholder submitted that roll-out obligations have no relevance in the era of auctioned spectrum. However, if the Government mandates roll-out obligations, those prescribed under the NIA for 2016 auction may be continued without any change. In case of new entrant with no spectrum holdings, roll-out obligations similar to 2300 MHz band may be prescribed.

Analysis

2.86 As mentioned earlier, spectrum in 3300-3400 MHz and 3400-3600 MHz bands is proposed to be put to auction for the first time in the country. Therefore, there is no precedence of roll-out obligations for these spectrum bands. However, a couple of International cases are available that are discussed below.

2.87 **No Roll-out Conditions imposed by OFCOM**-OFCOM recently (in April 2018) auctioned spectrum in 2300 MHz and 3400 MHz spectrum bands. On 11th July 2017, OFCOM issued a document[13] on "Award of the 2.3 and 3.4 GHz spectrum bands: Competition issues and Auction Regulations" which sets out Regulations for the award by auction of radio spectrum licences in the 2300 and 3400 MHz bands. OFCOM did not propose any roll-out obligations for the spectrum in any of these bands. The rational for not prescribing any rollout obligation provided in the OFCOM consultation paper dated 21st November 2016 was "*the technical characteristics of 2.3 and 3.4 GHz spectrum mean that it is suited to adding capacity, but is not an effective means of extending existing levels of mobile coverage*".

2.88 **Roll-Out Obligations imposed by Comreg:** In 2017, Ireland has auctioned 350 MHz of C-band spectrum (3410-3435 and 3475-3800 MHz) for 5G NR services[14]. As per the roll-out imposed on the successful bidders, all Licence holders must attain and maintain the rollout of a minimum number of base stations per Region (see Table below) within 3 years of Licence issue. A higher rollout obligation is imposed on licensees holding more than 100 MHz of spectrum rights in a region compared to those holding up to 100 MHz. Base stations

[13] OFCOM Document on "Award of the 2.3 and 3.4 GHz spectrum bands: Competition issues and auction regulations" dated 11th July 2017
URL: https://www.ofcom.org.uk/__data/assets/pdf_file/0022/103819/Statement-Award-of-the-2.3-and-3.4-GHz-spectrum-bands-Competition-issues-and-auction-regulations.pdf
[14] https://www.comreg.ie/publication/results-3-6-ghz-band-spectrum-award/

are required to be deployed in at least 4 counties in each non-urban region.

Table 2.18: Rollout base station obligation by region

Reference number of Region	Name of region	Number of rollout base stations to be worked and used	
		Licensee holding up to and including 100 MHz in the 3.6 GHz band in that region	Licensee holding over 100 MHz in the 3.6 GHz band in that region
1	Borders, Midlands and West	15	25
2	East	15	25
3	South East	15	25
4	South West	15	25
5	Dublin city and suburbs	10	15
6	Cork city and suburbs	2	4
7	Limerick city and suburbs	2	4
8	Galway city and suburbs	2	4
9	Waterford city and suburbs	2	4

2.89 Spectrum is a limited resource and it cannot be allowed to be hoarded and kept unused. It is to be ensured that the spectrum is put to use in an effective and efficient manner. With this rationale, certain roll-out obligations have been linked with all the access spectrum bands. However, these roll out obligations are with respect to coverage of prescribed DHQs/BHQ/SDCAs etc.

2.90 As the high frequency waves do not travel longer due to higher propagation loses, these are not suitable for extending mobile coverage to uncovered/remote areas. As relatively large bandwidth is available in the high frequency bands, these can be used to enhance the network capacity wherever required. Being high frequency spectrum band, 3300-3600 MHz band is likely to be used mainly to enhance the network capacity of the underlying network set up using

lower frequency bands. Further, this band is likely to be used for 5G and the TSPs will decide 5G rollout based on demand and affordability. Moreover, the standards of IMT 2020 are still in development stage and the maturing of technology/device eco-system will take even more time. Therefore, prescribing coverage related roll-out obligations may not be appropriate. Further, as per the draft National Digital Communication Policy (NDCP), 2018, DoT is envisaging to monitor efficient utilization of spectrum by conducting systematic audits of the spectrum allocated to both commercial and government organizations and deploy dynamic database systems for interference assessment. This will ensure that the spectrum in 3300-3600 MHz band is efficiently utilized. However, if no roll-out obligations are mandated for this band and at the same time, spectrum will be auctioned in other bands also, which may be sufficient to meet the current demand, a situation could arise where a TSP may acquire the spectrum in 3300-3600 MHz band and trade it after a prescribed period of two years to monetize its increased market value. Therefore, to avoid such a possibility, the Authority is of the view that spectrum trading in this band should be allowed after a lock in period of 5 years.

2.91 In view of the above, **the Authority recommends that no roll out obligations should be mandated for spectrum in 3300-3600 MHz band. However, to avoid any misuse of not mandating any roll-out obligations, the lock-in period for spectrum in this band for becoming eligible for spectrum trading should be 5 years instead of 2 years.**

F. Spectrum Cap

2.92 As per the NIA provisions of the recent auction, the overall spectrum cap for each of the service areas is calculated as 50% of the total spectrum assigned for telecom services in a particular band (intra-

band cap) and 25% of the total spectrum assigned for telecom services put together (inter-band cap) in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands. While calculating spectrum caps, the spectrum being put to auction was also taken into account. This definition does not include 3300-3400 MHz and 3400-3600 MHz bands as these were never put to auction. Now, since these bands are also proposed to be auctioned, above provision of spectrum cap needs to be reviewed. Therefore, in the Consultation Paper, the stakeholders were asked to comment whether there is a need to prescribe spectrum cap in bands 3300-3400 MHz and 3400-3600 MHz; and if yes, what spectrum cap provisions should be kept for these spectrum bands. The stakeholders were also asked whether these bands be treated as same or separate bands for the purpose of calculation of spectrum cap.

2.93 Some stakeholders were of the view that the spectrum caps needs to be relaxed. One stakeholder responded that there is a strong case for a significant relaxation or even removal of in-band spectrum caps and a relaxation in the overall band cap from 25% to 30%. The same approach must be followed in case of the 3300-3400 MHz and 3400-3600 MHz bands as well.

2.94 One stakeholder suggested that intra-band spectrum caps should be completely done away for all the spectrum bands; however inter-band cap of 25% should be retained while another stakeholder proposed that spectrum caps as currently defined ceiling of 25% of the 'total spectrum assigned' in all bands put together and 50% within a given band in each service area" be done away with.

2.95 One stakeholder was of the view that appropriate intra-band caps are essential to prevent potential spectrum grabbing or monopolization of the spectrum in a specific band by any single operator. Echoing the

same point of view, another stakeholder submitted that the present intra-band spectrum caps of 50% should be continued and same should be extended to new bands as well i.e. 3300-3400 MHz and 3400-3600 MHz.

2.96 As per one stakeholder, the channel bandwidth for this band is up to 100 MHz in 3GPP. Therefore, the spectrum cap for this band is proposed to be 100 MHz. A few stakeholders suggested that 3300-3400 MHz and 3400-3600 MHz bands should be treated as a single band for the purpose of calculating spectrum cap. One of these stakeholders submitted that a band specific limit of 40 MHz be imposed on the combined holding in 3300-3400 MHz and 3400-3600 MHz bands, while the another stakeholder proposed a cap of 70 MHz that a TSP should be permitted to hold in both these bands taken together.

Analysis

2.97 After the issue of Consultation Paper on 28th August 2017, the Authority received a communication from DoT on 29th September 2017. DoT informed that the Government had constituted an Inter-Ministerial Group (IMG) on "Stress in balance sheet in Select Sectors". The IMG, among others, reviewed the spectrum cap applicable for Telecom Service Providers (TSPs). IMG, in its report, stated that the issue of spectrum cap merits detailed examination and variety inputs from sectoral regulators and hence, DoT may consider the issue separately. In light of IMG report, DoT requested TRAI to provide its views on whether existing applicable band-wise spectrum cap of 50% of the total spectrum assigned in a band for an LSA and the over-all cap of 25% of the total spectrum assigned in an LSA across all bands should continue or needs review. DoT also requested that in the latter case, TRAI may consider providing new band-wise and overall spectrum cap.

2.98 On 21st November 2017, the Authority finalized its response to DoT after consultation with telecom service providers. In this response, the Authority inter-alia stated that:

"the Authority is of the view that the overall spectrum cap should be revised from the current limit of 25% to 35%."

"....the Authority is of the opinion that the current intra-band cap should be removed. Instead, there should be a cap of 50% on the combined spectrum holding in the sub-1 GHz bands (700 MHz, 800 MHz and 900 MHz bands)".

2.99 Agreeing with the Authority's opinion, DoT made the following amendments to the licence provisions on 19th March 2018:

"*Notwithstanding anything contained in NIA for auctions conducted for award of spectrum in the years 2012, 2013, 2014, 2015 and 2016, the limit of Cap for spectrum holding are hereby revised as detailed below:*

(a) The overall spectrum cap is revised from the current limit of 25% to 35%.

(b) The current Intra-band cap is removed and a Cap of 50% on the combined spectrum holding in the sub-1 GHz bands (700 MHz, 800 MHz and 900 MHz bands) is applicable.

(c) There shall be no Cap for individual or combined spectrum holding in above 1 GHz band.

……"

2.100 Since the issue of spectrum cap was examined by the Authority in November 2017 and DoT has accepted it as recently as March 2018, there is no need of its review and the existing provisions of spectrum cap may be extended to 3300-3400 MHz and 3400-3600 MHz bands. Accordingly, **the Authority recommends that the revised provisions of spectrum cap (i.e. 35% Overall cap and a Cap of 50% on the combined spectrum holding in the sub-1 GHz bands) should be extended to 3300-3600 MHz band also. Additionally, in**

3300-3600 MHz band, there should be a spectrum holding cap of 100 MHz per licensee.

G. Spectrum Audit

2.101 Access spectrum is a scarce natural resource and is the lifeline for wireless services and in particular mobile broadband. With the rise in number of smart phones & devices, the data usage has grown substantially in the past few years. The 'Digital India', which is a flag ship initiative of the Government, would result into increase in demand for higher data usage. Any amount of spectrum, if not put to use optimally and efficiently, result not only financial loss to the Government, but also hinders economic and social development of the country. All the Government agencies are assigned spectrum administratively. Therefore, it is essential to ensure that the spectrum assigned to them is put to optimal use. The Authority, on many occasions have recommended to the Government that spectrum audit should be conducted which are reproduced below:

"The Authority would undertake regular spectrum audit through appropriate means. The details of the audit procedure and frequency of the exercise would be finalised through a separate consultation process."

(TRAI's recommendations on "Spectrum Management and Licensing Framework" dated 11.05.2010)

"*TRAI may undertake regular spectrum audit for efficient management of available spectrum. For conducting audit of the spectrum, the licensees shall provide all data, reports, test equipments & other accessories etc. The Licensee will also permit inspection of its installations and network sites to TRAI personnel and fully cooperate in conducting the spectrum audit".*

(TRAI recommendations on "Terms and Conditions of Unified License (Access services)" dated 02.01.2013)

"*There is an urgent need for audit by an independent agency of all allocated spectrum both commercial as well as spectrum allocated to various PSUs/Government organizations. This ought to be a national priority and must be undertaken within 3 months."*

(TRAI's recommendations on "Delivering Broadband Quickly: What do we need to do?" dated 17.04.2015)

"There is an urgent need of audit for all allocated spectrum both commercial as well as spectrum allocated to various PSUs/ Government organizations. This should be done by an independent agency."

(TRAI's recommendations on Valuation and Reserve Price of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz Bands dated 27.01.2016)

2.102 DoT in its letter dated 1st April 2016, while referring back the recommendations of the Authority dated 27th January 2016 on 'Valuation and Reserve Price of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands' had, inter-alia, intimated that they shall internally audit the spectrum allocated to various PSUs / Government organizations within a period of 6 months and submit the report to the Telecom Commission.

2.103 After reconsidering the issue, the Authority in its response to the back reference dated 18th April 2016, inter-alia, responded as follows:

"The role of spectrum audit is of utmost importance. Audit by an independent agency through a transparent and objective mechanism is desired. However, if DoT intends to carry out audit by itself, it should be completed in a time-bound manner and its methodology and the outcomes should be shared with the Authority."

2.104 Subsequently, the Authority, vide its letters dated 21st October 2016, 3rd October 2017 and 30th July 2018, requested DoT to share the methodology and outcome of the spectrum audit with the Authority. However, response from DoT is still awaited.

2.105 The Authority is of the view that apart from making additional spectrum available it is important to ensure that the spectrum which has been allocated to the existing users is utilized optimally and efficiently. Accordingly, the role of spectrum audit is utmost important. Recognizing the need of spectrum audit, one of the

objectives of NTP 2012 is to "*promote efficient use of spectrum with provision of regular audit of spectrum usage*". The recently released Draft National Digital Communications Policy – 2018 by DoT also recognizes the need for spectrum audit and in order to achieve the mission of 'Connect India', one of the strategies identified is:

"Monitoring efficient utilization of spectrum by conducting systematic audits of the spectrum allocated to both commercial and government organizations and deploy dynamic database systems for interference assessment is one of the strategies for achieving."

2.106 In view of the above, the Authority reiterates its earlier recommendation that **there is an urgent need of audit of all allocated spectrum both commercial as well as spectrum allocated to various PSUs/ Government organizations. This should be done by an independent agency on a regular basis.**

CHAPTER-III: VALUATION AND RESERVE PRICE OF SPECTRUM

3.1 This chapter deals with various aspects of the valuation and reserve price of the different spectrum bands that have been discussed in previous two chapters i.e. 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz spectrum bands.

3.2 Radio Spectrum is a scarce resource [15] and the need for understanding its economic value for efficient spectrum management has been widely discussed in research literature[16]. Herbert Hoover, the then US Secretary of Commerce, said in 1925: *"There is no more spectrum available*" and ever since shortage of spectrum has been projected as a factor delaying the development of society. Telecom Regulators and Administrations all over world have faced the demand to release more spectrum. Prior to spectrum auction in 2016, India too was not an exception to this phenomenon and the Spectrum on offer was always in short supply [17]. For the first time, supply of spectrum in India was in the excess of Demand in 2016. Gregory Staple and Kevin Werbach had argued in 2004 that new technologies that use spectrum more efficiently and more cooperatively, unleashed by regulatory reforms, may soon overcome the spectrum shortage [18] ,but the state of affairs projected by them is yet to materialise. At the same time a huge upsurge in the consumer demand for mobile telecom services that would ride upon the fast growing 4G LTE and fast evolving 5G technologies has been projected by the experts [19] .These developments necessitate release of more spectrum and, in turn, valuation of spectrum bands being offered for

[15] http://www.ictregulationtoolkit.org/toolkit/1.6,ITU,Geneva
[16] Morten Falch, & Reza Tadayoni, "Economic analysis of the radio spectrum for regulatory purposes",2002, Center for Tele-Information, Technical University of Denmark
[17] Ref.Table1(chapter 1) of these recommendations
[18] Gregory Staple and Kevin Werbach,"The End of Spectrum Scarcity", https://spectrum.ieee.org/telecom/wireless/the-end-of-spectrum-scarcity
[19] Ericsson Mobility Report,2018;GSMA & GSA Reports 2018

auction for determining reserve prices. Radio Spectrum by itself does not have any value but the possible value that could be generated by its deployment for telecom services makes it valuable. In other words the difference between relative valuations of two different spectrum bands would be dependent on the respective values generated by the services that could be deployed on these bands. Theoretically, it should be easy. However, unlike most other assets, estimation of value of this social and economic intangible asset is a far more complex and painstaking exercise[20].

3.3 Valuation of spectrum differs with context and time period in which it is valued and is also dependent upon the information about the market understanding of all the relevant information about the specific item. However, these pieces of information would necessarily not result in identical valuation if done by different entities, e.g. Regulator would use the same information and arrive at a particular value and the policy maker or the Government may arrive at a different value. Similarly the Telecom Service Providers, and analysts / consultants interested in the spectrum would arrive at different values based on respective business plan/ information which would not be readily available with regulator / policy maker.

3.4 There is a need to achieve a judicious balance between the three main considerations of Spectrum Valuation, namely (a) Efficient Assignment, (b) Maximization of Consumer Welfare and (c) Optimal Value for the Public Natural Resource[21]. The Authority has, in the past, depending upon the information available, used various methodologies for valuation of spectrum, which can be broadly classified as variations of (i) Discounted Cash Flow (DCF), (ii) Cost Savings or avoidance, (iii) Multivariate Regression Analysis and (iv)

[20] Coleman Bazelon Giulia McHenry, "Spectrum Value" (August 28, 2012), http://ssm.com/abstract=2032213

[21] GSMA, Spectrum Pricing in Developing Countries Evidence to support better and more affordable mobile services, July 2018

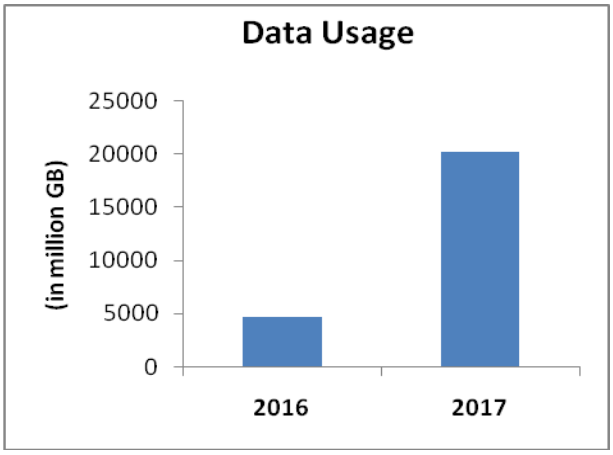
Market Comparisons. Further, the Authority, since 2013, has used average of various alternative valuations methods and benchmarked the average value with recent auction discovered price of the spectrum. The ITU technical report [22] titled "Methodologies for valuation of spectrum" discusses these methodologies in detail. It has now been globally recognized that the market revealed prices through well designed auctions, are closest to reality. Similar opinion has been expressed by many of the stakeholders in the current consultation exercise[23]. For the 700MHz band, which was on offer in 2016 but could not be sold and for the new 3300-3400 MHz/ 3400-3600 MHz specific bands which are on offer for the first time, the Authority does not have the kind of data, it has for other bands. Therefore, the Authority has relied upon market revealed prices of a comparable spectrum band and applied a technical efficiency factor to arrive at valuation of the spectrum bands being put to auction for the first time. Further, the Authority has maintained in the past that the spectrum valuation and the reserve prices would undergo changes with the emergence of new facts from time to time[24].

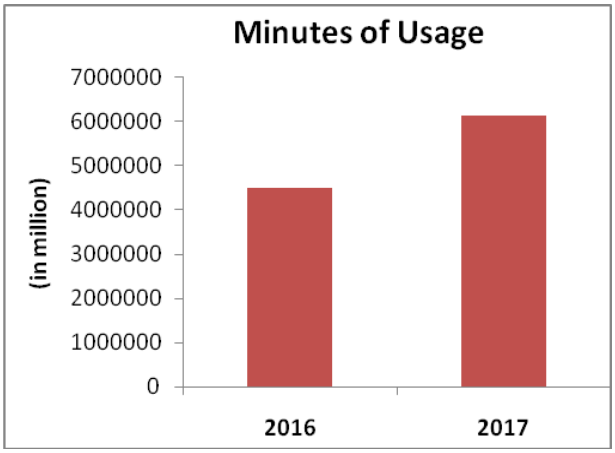
3.5 There have been rapid developments in Information and Communication Technology and overall business environment along with significant changes in the consumer behavior. Our recommendations would, therefore, take into account the new developments e.g. data usage has increased from 4642 GB (in million) in 2016 to 20092 GB (in million) in 2017 showing year on year growth of approximately 333%. Also, total minutes of usage have increased from 4491841 (in million) in 2016 to 6134143 (in million) in 2017 showing year on year growth of 36.5%.[25]

[22] ITU-T Technical Report, "Methodologies for valuation of spectrum", April 2017.
[23] Para no 3.26 of the current recommendations
[24] TRAI's Recommendations on Spectrum Valuation , 2013
[25] Ericsson Mobility Report June, 2018

MOBILE TRAFFIC (2016-17)

Year-on-year data on total minutes of usage and total data usage in India





Source: TRAI Data

Subscription and Usage data

	2017	2023	CAGR
Worldwide mobile subscriptions	7.8bn	8.9bn	2%
Worldwide Smartphone subscriptions	4.3bn	7.2bn	9%
Worldwide mobile broadband subscriptions	5.3bn	8.3bn	8%
Worldwide LTE subscriptions	3.4GB	17GB	12%
Worldwide monthly data traffic per active Smartphone	15EB	107EB	31%
Worldwide total monthly mobile data traffic	2.7bn	5.5bn	39%

Source: Ericsson Mobility Report June, 2018

3.6 Globally number of mobile subscriptions grew @ 4% year-on-year, reaching 7.9 billion in the first quarter of 2018. China had the most net additions during the quarter (+53 million), followed by India (+16 million), Indonesia (+6 million), Nigeria (+3 million) and Bangladesh

(+2 million).[26] The high growth in India during the quarter is the result of intense competition among operators, driving up the number of subscribers mainly through multiple subscriptions.

3.7 Outlook for telecom services in the medium-term will be shaped by a number of factors viz. increasing monthly addition of subscriber base and minutes of usage, explosive increase in data usage, increasing reach of networks and affordability, intensified fierce competition and dramatic fall in tariff etc. With the adoption of 4G and LTE enabled smart phones, mobile broadband subscription has increased manifold. Additionally, multiple device ownership patterns are increasingly popular across different sections of society and regions. At the same time the telecom tariffs in India[27] and abroad[28] have declined.

3.8 Radio Spectrum is the building block of wireless mobile telecom service. The demand for radio spectrum is a derived demand, which means that it originates from the demand of telecom services of all descriptions. Therefore, the valuation of spectrum becomes multivariate exercise incorporating whole range of factors on demand and supply side including technical developments and features of specific spectrum bands. The valuation and determination of reserve price of spectrum depends on multiple factors such as the assessment of demand for telecom services in its all variants, revenue, operating expenses, Earnings before interest, taxes, depreciation and amortization (EBITDA), cost of network, development of ecosystem and other special features of a particular band etc. For certain spectrum bands, the Authority has historical information – both financial and non-financial – which helps in

[26] https://www.ericsson.com/en/mobility-report/reports/june-2018/mobile-subscriptions-worldwide-q1-2018

[27] Yearly Performance Indicators, Indian Telecom Sector,2017 and Quarterly report on the Indian Telecom Services Performance Indicators, January-March 2018, TRAI

[28] https://www.gsma.com/mobileeconomy/wp-content/uploads/2018/05/The-Mobile-Economy-2018.pdf

assessing the value of such spectrum bands and the reserve price of those spectrum bands for the auction but for other bands like 700 MHz, 3300-3400 MHz and 3400-3600 MHz, it does not have the benefit of adequate information.

3.9 The Authority has kept in view the various developments/observations/ limitations mentioned in this and previous two chapters while drafting its current recommendations.

VALUATION SPECTRUM: SINGLE APPROACH *VERSUS* MULTIPLE APPROACHES

3.10 To arrive at the value of a spectrum band, various approaches specific to respective spectrum band, have been used and the rationale for the same has been explained in the relevant part of these recommendations. As explained in the earlier recommendations of TRAI about spectrum valuation and pricing, in 2013 (and also in 2016), various approaches used in valuing spectrum band have their merits and limitations. Rather than relying on one valuation approach, it may be prudent to rely on a number of approaches to arrive at final valuation. In view of this, it would not be desirable to say deterministically that only one of these valuations is absolutely the right approach. Therefore, the Authority in its September 2013 Recommendations and its subsequent Recommendations on valuation and reserve price of spectrum (for different spectrum bands from time to time) took the view that rather than following a deterministic approach, it is best to work with a probabilistic average valuation (through simple mean) that captures the range of possible valuations. Accordingly, the following questions were raised in this regard in the Consultation Paper (CP) for seeking the comments of the stakeholders:

Q.16. Whether value arrived at by using any single valuation approach for particular spectrum band should be taken as the

appropriate value of that band? If yes, please suggest which single approach/ method should be used. Please justify your response.

Q.17 In case your response to Q16 is negative, will it be appropriate to take the average valuation (simple mean) of the valuations obtained through the different approaches attempted for valuation of a particular spectrum band, as adopted by the Authority since September 2013 recommendations? Please justify your response.

3.11 With regard to above questions, many of the stakeholders were of the view that the market discovered price of spectrum in the October 2016 auction may be used for arriving at the valuation of 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands and no other valuation method is required.

3.12 Some operators stated that no single valuation approach for particular spectrum band should be taken as the appropriate value of that band. One of the stakeholders was of the view that in addition to technical efficiency, other parameters like demand of particular band, financial condition/ revenue of telecom sector, availability of ecosystem of a particular band should also be considered in determination of valuation of any spectrum band.

3.13 Some stakeholders were of the opinion that it was not possible to deterministically ascertain if any one valuation is the 'right' valuation. Each model has certain strengths as well as limitations. Where some models better capture intrinsic technical features, others are more strongly grounded in economic and market realities. So, no single model should be used.

3.14 One stakeholder has suggested that if any new spectrum band is put to auction, for which there is no auction determined price available, a

single valuation approach based on technical efficiency seems to be more reasonable and acceptable method of valuation for that band.

3.15 The Authority has examined all the comments of stakeholders. After examining these, the Authority is of the consistent and considered view that it is not possible to say deterministically that any one method/ approach is the right method/ approach of spectrum valuation. Each method/ approach/ model has certain strengths as well as limitations. Some models capture intrinsic technical features better, whereas others are based on economic and market realities.

3.16 The Authority since its September, 2013 spectrum recommendations has been determining spectrum valuation, by taking the simple mean of the valuations obtained from the various valuation approaches, on the assumption of equal probability of occurrence of each valuation approach[29]. **Therefore, the Authority has decided to continue with the same methodology.**

SPECTRUM VALUATION APPROACHES

3.17 With regard to the various spectrum valuation approaches followed by the Authority, the following question was raised in the CP:

Q.15 Is there any other valuation approach than discussed above or any international auction experience/ approach that could be used for arriving at the valuation of spectrum for 700/800/900/1800/2100/2300/2500/3300-3400/3400-3600 MHz bands? Please support your suggestions with detailed methodology and related assumptions.

3.18 Majority of the stakeholders supported that auction determined prices of October 2016 spectrum auction could be used for arriving at

[29] As was done in Recommendations of September 2013 on 900 MHz & 1800 MHz band, February 2014 on 800 MHz band, October 2014 on 900 MHz & 1800 MHz band and December 2014 on 2100 MHz band and January, 2016 for 800 MHz. 900 MHz, 1800 MHz & 2100 MHz spectrum bands

the valuation of different spectrum bands. Stakeholders agreed with the approach of taking average of valuations obtained through different methodologies. However, one of the stakeholders was of the view that while deciding valuation of any spectrum band, various other parameters such as technical efficiency, demand of spectrum band, financial condition of telecom sector should also be considered.

3.19 One of the stakeholders stated that averaging of valuations obtained through the different approaches would be a more suitable approach and it should be continued in the present exercise also and further asserted that single valuation approach should not be relied upon.

3.20 None of the stakeholders have given specific inputs on the valuation approaches used in the past spectrum valuation exercises.

3.21 After considering the comments of stakeholders, the Authority has decided to continue with different approaches adopted for different spectrum bands in previous recommendations on valuation and reserve price. As followed in the previous valuation exercises, in the current exercise too the common approaches/ methodologies have been discussed first and, thereafter, approaches/ methodologies specific to particular spectrum band have been deliberated upon.

Technical Efficiency

3.22 An alternative approach used for spectrum valuation could be based on the relative technical efficiency of the band with another band. In the past valuation exercises since 2012, the Authority estimated the value of 700 MHz[30], 800 MHz[31], 900 MHz[32] and 2100 MHz[33]

[30] Ref. Para 3.75 of January 2016 Recommendations
[31] Ref . Para 3.1 to 3.4 of December 2013 Consultation Paper on Valuation and Reserve Price of 800 MHz band
[32] Ref. Para 4.45 to 4.47 of September 2013 Recommendations
[33] Para 3.6 and 3.7 of December 2014 Consultation Paper and Para 3.8 to 3.10 of December 2014 Recommendations.

spectrum based on their respective technical efficiency vis-à-vis 1800 MHz spectrum.

3.23 Consistent with its earlier valuation exercises, in the current exercise too, the Authority has decided that one of the approach to valuations of 700 MHz, 800 MHz, 900 MHz, 2100 MHz spectrum bands could be worked out by using technical efficiency factor vis-à-vis 1800 MHz spectrum.

Use of Last Auction Determined Prices/ Indexed Prices

3.24 During the last auction held in October 2016, for 800 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands, spectrum was sold at reserve prices in most of the LSAs; only in some of LSAs, the sale at higher than reserve price could be achieved. The auction determined price of October 2016 represents the bidders' preferred price for spectrum put on auction in the respective LSA. Keeping in view, following questions were raised in the CP for the use of last auction determined prices as one of the possible values for valuation of spectrum in respective bands.

Q.7. Whether the prices revealed of various spectrum bands in the October 2016 auction can be taken as the value of spectrum in the respective band for the forthcoming auction in the individual LSA? If yes, would it be appropriate to index it for the time gap since the auction held in October 2016. If indexation is to be done then at what rate?

Q.8 If the answer to above question is negative then, whether as per the practice adopted by TRAI in the previous valuation exercise, the valuation for respective spectrum bands be estimated on the basis of various valuation approaches/methodologies including those bands (in a LSA) for

which no bids were received or spectrum was not offered for auction?

3.25 As mentioned earlier, many stakeholders were of the opinion that the auction determined price of previous spectrum auction held in October, 2016 could be used for arriving at the valuation of the various spectrum bands and indexing the value of the spectrum for the time gap should be discontinued.

3.26 The comments of the stakeholders have been examined by the Authority with reference to auction held in 2016. As can be seen from Tables 3.1 to 3.7 of the current Consultation Paper, during October 2016 auction, spectrum in most of the LSAs was sold at the reserve price; and in some of LSAs, the sale at higher than reserve price could be achieved. Authority maintains the view that market price achieved as an outcome of an auction is the best available indicator of the spectrum. Further, the Authority is of the view that the auction revealed prices of preceding two years would be reasonable to be considered for the purpose of valuation in the present exercise. Therefore, the Authority recommends that the prices revealed in the last auction held in October 2016 be taken as one of the value of spectrum in the respective band for the forthcoming auction, duly indexed, if these are more than one year old.

3.27 In the past spectrum valuation exercises, the Authority had used SBI PLR rate/ SBI Base Rate for indexing the last auction determined prices as one of the possible valuations in spectrum valuation exercises for valuing various spectrum bands.

3.28 In this regard, the Authority also took note that the 'Marginal Cost of Funds based Lending Rates (MCLR) system' has replaced the base rate system with effect from 1st April 2016[34]. Therefore, Authority is

[34]R B I Notification No. RBI/2015-16/273 DBR.No.Dir.BC.67/13.03.00/2015-16 December 17, 2015

of the view that the Marginal Cost of Funds based Lending Rates (MCLR) represents the most realistic rate at which indexation should be carried out and should replace SBI base rate for the indexation purposes.

3.29 **Thus, the Authority recommends that the auction determined price of 800 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz spectrum bands auctioned in last two years, duly indexed with MCLR is to be taken as one of the possible values in the respective spectrum bands in the present spectrum valuation exercise.**

Valuation of 1800 MHz Spectrum

3.30 While determining the value of 1800 MHz spectrum band, the Authority has used various valuation approaches/methods which are discussed below:

Production Function Approach[35]

3.31 None of the stakeholders has commented on the use of production function approach as one of the possible valuation approach for 1800 MHz spectrum band.

3.32 This approach was previously adopted by the Authority in its Recommendations on spectrum and reserve price of September 2013 (Detailed Methodology at Annexure 4.3 of the report), October 2014 and January 2016. Under this approach, separate models have been run for Metro (Delhi and Mumbai), Kolkata, Category A, Category B &

[35] Production Function approach - For arriving at one possible value of 1800 MHz spectrum band, spectrum and BTS can be taken as two factor inputs to estimate a production function to produce mobile traffic or minutes of usage. This approach is based on the assumption that the two inputs (spectrum and BTS) can be substituted for each other over a range of output. An optimal mix will be used by the TSPs to produce the required traffic and this optimal mix is determined by input prices. A higher charge for spectrum will induce TSPs to substitute spectrum for the less expensive BTS to produce the same number of minutes, and vice versa. One way of estimating the value of 1800 MHz spectrum is to take a panel data set of minutes of traffic, spectrum allocated and BTS in different LSAs over a past period and estimate the coefficients of the production function which can then be used to derive the value of spectrum across LSAs.

Category C with updated data for 2016-17. The assumed growth of subscribers, minutes of usage, number of SMS and data usage has been indicated in Annexure 3.1.

3.33 Production function approach provides a reasonable approximation to equivalent cost savings on BTS conserved by deploying an additional unit of spectrum. Therefore, the Authority has followed the production function approach as one possible valuation of 1800 MHz spectrum band. The results obtained by using this approach are given in Annexure 3.2.

Revenue Surplus Model[36]

3.34 None of the stakeholders has commented on the use of revenue surplus approach as one of the possible valuation approach for 1800 MHz spectrum band.

3.35 This approach was previously adopted by the Authority in Recommendations of October 2014 (Detailed Methodology at Annexure 3.3) and Recommendations of January 2016.

3.36 A bottom-up approach has been adopted with separate revenue surplus projections done for each LSA with updated data for the year 2016-17. The assumed growth of subscribers and revenue has been indicated in Annexure 3.1. The per line Investment (Capex) has been taken Rs. 1000 per subscriber. The investment per subscriber does not include spectrum auction fee and one time licence fee. The figures given by telecom service providers to TRAI for the year 2016-17 have been used as the base figures in this exercise. To determine the value per MHz of 1800 MHz spectrum, the NPV of revenue surplus of each LSA is divided by the total equivalent available spectrum in that LSA.

[36] Revenue Surplus Model - The value of spectrum could be estimated from the perspective of an access service provider willing to invest in spectrum to realize the net revenue potential/revenue surplus from the GSM segment over the licence period horizon of 20 years for acquiring 1800 MHz spectrum.

3.37 Based on the assumptions (Detailed Methodology at Annexure 3.3 of October 2014 Recommendations) and information available with TRAI, the values of 1800 MHz spectrum (per MHz) using revenue surplus approach are given in Annexure 3.2.

Producer Surplus Approach on Account of Additional Spectrum[37]

3.38 This approach was previously adopted by the Authority in Recommendations of September 2013 (Detailed Methodology at Annexure 4.2 of the Recommendations), Recommendations of October 2014 and Recommendations of January 2016. None of the stakeholders have offered any comments on this method.

3.39 To determine the value under this approach, the assumed growth of number of subscribers, number of voice MOU, number of SMS and amount of data usage has been indicated in Annexure 3.1. The number of subscribers, voice MOU, SMS and data usage per subscriber per month have been projected on the basis of the information received in TRAI.

3.40 The results obtained by using Producer Surplus approach as one possible valuation of 1800 MHz spectrum band are at Annexure 3.2.

Multiple Regression Approach[38]

3.41 Another possible approach to value spectrum based on market information revealed from the auction of October 2016 of 1800 MHz

[37] Producer Surplus approach - Spectrum can also be valued on the basis of this approach. As there is an inverse relationship between the quantum of spectrum allocated and the expenditure on radio access network (RAN) required for serving a particular level of demand, the allocation of additional spectrum to an existing TSP will create a Producer Surplus. The model is a bottom-up approach to determine the opportunity of cost savings to an average Telecom Service Provider (TSP) upon expenditure in the Radio Access Network (RAN) and spectrum usage charge (SUC) during the next 20 years upon getting additional spectrum (opportunity/MHz). The opportunity of the net savings in expenditure made by the TSP has been termed as 'Producer Surplus'

[38] Multiple Regression Approach - Linear regression establishes a relationship between a scalar dependent variable denoted as Y and one or more explanatory variables denoted as X. If only one explanatory variable is used, it is called simple linear regression; for more than one explanatory variable, it is called multiple linear regression

spectrum band. The prices realized through last Auction in the LSAs can be correlated with other relevant variables to estimate the values of spectrum in the LSAs where spectrum was auctioned. The exercise can be done using multiple variable regressions. These variables have been updated for latest information/data. The sample size of market revealed information was taken as per October 2016 auction in 1800 MHz spectrum band.

3.42 In this regard, question was raised in the CP on the use of various valuation approaches/ methodologies which includes Market Data Analysis as one of the possible values in valuation of spectrum in respective bands.

3.43 None of the stakeholders has offered any comment on this approach.

3.44 Using this approach, the valuation of 1800 MHz band in eighteen LSAs (where the auction determined prices of October 2016 auction were available) was taken into consideration using this valuation approach. The results obtained by using Multiple Regression approach as one possible valuation of 1800 MHz spectrum band are at Annexure 3.2.

Valuation of 900 MHz Spectrum

3.45 900 MHz spectrum band was put to auction in 2016 in only four LSAs but no bids were received in any of the LSAs. For the valuation of 900 MHz band, technical efficiency, economic efficiency approach, last auction determined price and where auction determined market prices of 900 MHz were not available in any of the LSA, the auction determined price of 800 MHz band, if available, were utilized as one amongst the possible valuations of spectrum. These methodologies / approaches have already been touched upon in the previous paras / footnotes and the TRAI's recommendations of January 2016. Based

on the methodologies/ approaches adopted for 900 MHz, the valuation arrived at for 900 MHz spectrum band are at Annexure 3.3.

Valuation of 800 MHz and 2100 MHz Spectrum

3.46 As adequate data points of 3G and CDMA such as revenue, subscribers, minutes of usage and other performance indicators are not available, the Authority is of the view that there is no other option available except to use the last auction determined price and technical efficiency factor with regard to valuation of 800 MHz and 2100 MHz spectrum bands. Both the methodologies/ approaches have been described in detail in the preceding paras/ footnotes.

3.47 Based on the above methodologies/ approaches, the valuation arrived at for 800 MHz spectrum band are at Annexure 3.4 and the valuation arrived at for 2100 MHz spectrum band are at Annexure 3.5**.**

ARRIVING AT AVERAGE VALUATION OF 1800 MHz, 800 MHz, 900 MHz and 2100 MHz SPECTRUM.

3.48 In view of various valuation approaches adopted for different spectrum bands and discussion in preceding paras, the Authority has arrived at an expected average valuation for 1800 MHz, 900 MHz, 800 MHz and 2100 MHz spectrum as the simple mean of the various valuations that have been adopted and given at Annexure 3.2, Annexure 3.3, Annexure 3.4 and Annexure 3.5 respectively.

3.49 The Authority is of the view that any determination of the value of spectrum should be tempered by revealed preferences (realized prices) of the market discovered in the last two years.

3.50 Consistent with previous approach adopted, October 2016 market revealed price (duly indexed) wherever available for respective band can serve as a benchmark price representing a lower bound while estimating the valuation of such band. Therefore, **the Authority**

recommends that the average expected valuation of spectrum band in a LSA should be the higher of the two figures – (i) average expected valuation of that band based on simple mean or (ii) the auction determined price of October 2016 (duly indexed). Accordingly, the recommended average expected value of 1800/900/800/2100 MHz spectrum bands for each LSA is tabulated below:

Table 3.1
Recommended Average Value Per MHz

(Rs. in crore)

LSA	Category	Average Value per MHz of 1800 MHz	Average Value per MHz of 900 MHz	Average Value per MHz of 800 MHz	Average Value per MHz of 2100 MHz
Delhi	Metro	457.42	NA	800.48	635.11
Mumbai	Metro	560.82	NA	981.44	528.50
Kolkata	Metro	173.28	NA	303.24	143.82
Andhra Pradesh	A	278.58	NA	487.51	231.22
Gujarat	A	272.85	465.96	446.51	226.46
Karnataka	A	136.85	297.46	239.49	113.59
Maharashtra	A	364.56	NA	637.98	390.93
Tamilnadu	A	124.53	293.13	217.92	394.37
Haryana	B	56.52	127.46	98.91	63.05
Kerala	B	112.18	NA	196.32	202.91
Madhya Pradesh	B	101.98	NA	178.47	84.65
Punjab	B	94.90	NA	162.95	104.32
Rajasthan	B	105.36	NA	265.94	NA
U. P. (East)	B	152.64	326.93	261.77	126.40
U.P. (West)	B	114.99	263.54	201.22	95.44
West Bengal	B	52.73	NA	92.29	43.77
Assam	C	45.86	NA	NA	38.06
Bihar	C	109.52	251.13	191.67	98.59
Himachal Pradesh	C	18.34	NA	32.10	15.22

Jammu & Kashmir	C	21.13	NA	NA	15.08
North East	C	21.51	NA	NA	17.85
Orissa	C	33.77	NA	59.10	43.56

RESERVE PRICE OF 800 MHz, 900 MHz, 1800 MHz and 2100 MHz SPECTRUM BANDS

3.51 A reserve price refers to the minimum amount that the owner of an item will accept as the winning bid in an auction. The concepts of auction efficiency; revenue maximization; the RP in an auction; and various international practices were discussed in detail in the Consultation Paper dated 23rd July 2013 on 'Valuation and Reserve Price of Spectrum'. The Authority, in its past Recommendations on different bands (April 2012. September 2013, February 2014, October 2014, December 2014 and January 2016) had followed a general principle that the reserve price should be fixed at 80% of the average valuation for a spectrum band.

3.52 With regard to the reserve price, the following questions were raised in the CP:

Q.18. Is it appropriate to recommend Reserve price as 80% of the value? If not, then what should be the ratio adopted between the reserve price for the auction and the valuation of the spectrum in different spectrum bands and why?

Q.19 Whether the realized / auction determined prices achieved in the October 2016 auction for various spectrum bands can be taken as the reserve price in respective spectrum bands for the forthcoming auction? If yes, would it be appropriate to index it for the time gap since the auction held in October 2016? If yes, then at which rate the indexation should be done?

3.53 Most of the stakeholders were of the opinion that the auction determined prices of the October 2016 auction for spectrum bands can be taken as the reserve price for the forthcoming auction.

3.54 Few of the stakeholders were also of the opinion that reserve price should be fixed at 50% of the spectrum valuation.

3.55 Reserve Price is the starting point for an ascending price auction and bidding is a means to true price discovery. It is a well-known principle that RP should not be fixed too close to the estimate of valuation. The Authority has in its all previous recommendations on access spectrum since 2012 has recommended reserve price at 80% of average valuation of the respective band. Further regardless of the results of valuation of spectrum, if a certain reserve price has recently been rejected by the market, there is no point in setting a higher reserve price. Consistent with its earlier Recommendations, the Authority is of the view that the reserve price for the forthcoming auction of 800 MHz, 900 MHz, 1800 MHz and 2100 MHz spectrum bands be fixed at 80% of the average valuation. The 80% of average valuation is given in Annexure 3.6 for 1800 MHz band, Annexure 3.7 for 800 MHz band and Annexure 3.8 for 2100 MHz band.

3.56 To accelerate the pace of investment in telecom infrastructure in the North East and Jammu & Kashmir and in consistent to previous recommendations, **the Authority recommends that the reserve price for North East and Jammu & Kashmir LSAs in 800 MHz band, 900 MHz band, 1800 MHz band and 2100 MHz band may be fixed at a discount of 50% on the reserve price. The discount in North East and Jammu & Kashmir LSAs will also be given while arriving at reserve prices of other spectrum bands.**

3.57 Further while arriving at RP for forthcoming auction, the Authority is of the consistent view that the significance of market prices revealed in the auctions held in recent past cannot be ignored and need to be

factored in for arriving at the RP. It is consistent view of the Authority that market price revealed as an outcome of a competitive, transparent bidding process is best available value placed on the spectrum. Therefore, the market revealed prices in previous auction(s) held in last two years can be considered for the reserve price estimation.

3.58 After taking into consideration the bidding pattern, prices achieved and the time elapsed since last auction, it would be fair to assume that offered reserve price in a spectrum band in forthcoming auction should not be lower than the October 2016 auction determined prices (duly indexed) in that band. In other words, auction revealed price in last two years can serve as a benchmark representing a lower bound while arriving at RP (after discount, if any) for the forthcoming auction.

3.59 In view of above, **the Authority recommends that the reserve price for 800 MHz, 900 MHz, 1800 MHz and 2100 MHz bands**

(i) should be higher of the two figures – 80% of the average valuation of spectrum band in the LSA or the price realised in the October 2016 auction (duly indexed);

(ii) in LSAs where no spectrum was offered in October 2016 auctions, reserve price should be 80% of average valuation; and

(iii) in LSAs where spectrum was offered in October 2016 auction but remained entirely unsold, the reserve price should be lower of the figures – 80% of average valuation or the reserve price as fixed in October 2016 auction.

3.60 Accordingly, auction revealed price in last two years can serve as a benchmark representing a lower bound while arriving at RP (after discount, if any) for the forthcoming auction, which is given in

Annexure 3.6 for 1800 MHz band, Annexure 3.7 for 800 MHz band and Annexure 3.8 for 2100 MHz band.

3.61 **The recommended reserve price of 800 MHz, 900 MHz, 1800 MHz and 2100 MHz spectrum bands for each LSA is tabulated below:**

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)
IN 800 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	640.39	640
Mumbai	Metro	727.00	727
Kolkata	Metro	160.00	160
Andhra Pradesh	A	390.01	390
Gujarat	A	384.56	385
Karnataka	A	191.59	192
Maharashtra	A	510.38	510
Tamil Nadu	A	174.34	174
Haryana	B	57.00	57
Kerala	B	157.06	157
Madhya Pradesh	B	142.78	143
Punjab	B	156.70	157
Rajasthan	B	265.94	266
U. P. (East)	B	251.06	251
U.P. (West)	B	160.98	161
West Bengal	B	73.83	74
Bihar	C	136.00	136
Himachal Pradesh	C	24.00	24
Orissa	C	47.28	47

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)

IN 900 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Gujarat	A	372.77	373
Karnataka	A	237.97	238
Tamil Nadu	A	234.51	235
Haryana	B	101.97	102
U. P. (East)	B	261.54	262
U.P. (West)	B	210.83	211
Bihar	C	200.91	201

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)

IN 1800 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	457.42	457
Mumbai	Metro	560.82	561
Kolkata	Metro	173.28	173
Andhra Pradesh	A	278.58	279
Gujarat	A	272.85	273
Karnataka	A	109.48	109
Maharashtra	A	364.56	365
Tamil Nadu	A	99.62	100
Haryana	B	56.52	57
Kerala	B	95.15	95
Madhya Pradesh	B	95.15	95
Punjab	B	88.27	88
Rajasthan	B	105.36	105
U. P. (East)	B	152.64	153
U.P. (West)	B	114.99	115
West Bengal	B	52.73	53
Assam	C	45.86	46
Bihar	C	87.62	88
Himachal Pradesh	C	18.34	18
Jammu & Kashmir	C	14.90	15
North East	C	12.61	13
Orissa	C	27.02	27

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)

IN 2100 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	635.11	635
Mumbai	Metro	528.50	528
Kolkata	Metro	115.06	115
Andhra Pradesh	A	184.98	185
Gujarat	A	181.17	181
Karnataka	A	90.87	91
Maharashtra	A	390.93	391
Tamil Nadu	A	394.37	394
Haryana	B	63.05	63
Kerala	B	202.91	203
Madhya Pradesh	B	67.72	68
Punjab	B	104.32	104
U. P. (East)	B	126.11	126
U.P. (West)	B	76.35	76
West Bengal	B	35.02	35
Assam	C	30.45	30
Bihar	C	98.59	99
Himachal Pradesh	C	12.18	12
Jammu & Kashmir	C	12.61	13
North East	C	6.00	6
Orissa	C	43.56	44

VALUATION AND RESERVE PRICE OF 2300 MHz SPECTRUM BAND

3.62 The 2300 MHz band is used by mobile operators for LTE network deployments. Its short range permits deployment of dense coverage for maximum capacity. Consequent upon liberalisation of spectrum, the TSPs have flexibility to deploy LTE using 2300 MHz (TDD LTE) band as a single band or as part of a multi-band network. Since this spectrum band will be put to auction, determination of its valuation is required.

3.63 The valuation of spectrum of 2300 MHz band is dependent on the availability of financial and non-financial factors pertaining to this band. The auction of 2300 MHz band was done in 2010 as well as in 2016. However, unlike other spectrum bands (800 MHz/900 MHz/1800 MHz/2100 MHz), due to partial operational services on this band adequate information with regard to cost, revenue and other financial and non-financial aspects is not available with the Authority at this point of time.

3.64 As in January 2016 recommendations, due to non-availability of any financial or non-financial information, has estimated the valuation of 2300 MHz band by indexing the market determined prices of 2010 auctions using a suitable indexation factor. This was done as the NIA of 25th February 2010 (Para 4.7) for the 'Auction of 3G and BWA Spectrum' stipulates that in case of auction within one year from date of completion of relevant auction, the reserve price would be same as successful bid amount for the respective LSA. Due to late start of services under this band, again for the current valuation exercise, paucity of relevant data continues for the 2300 MHz spectrum band. In view of above, the stakeholders were requested to respond to the following questions in the CP:

Q.11 Whether the value of October 2016 auction determined prices be used as one possible valuation for 2300 MHz

spectrum for the current valuation exercise? If yes, would it be appropriate to index it for the time gap since the auction held in October 2016? Please justify your response with supporting documents/ report(s), if any.

Q.12 Whether the value of the 2300 MHz spectrum should be derived by relating it to the value of any other spectrum band by using technical efficiency factor? If yes, which band and what rate of efficiency factor should be used? If no, then which alternative method should be used for its valuation? Please justify your response with rationale and supporting documents.

3.65 In their responses, majority of the stakeholders were of the view that the market discovered price of spectrum in the October, 2016 auction be considered for arriving at the valuation of 2300 MHz band. One of the stakeholders mentioned that the GST regime, current financial stress and fierce competition should also be considered while valuation as all these factors would have an impact on the price of spectrum. Most of the stakeholders commented that there is no need to index the auctioned determined price for the time gap on the grounds that indexing assumes that the price of spectrum will keep going up, which may not be the case in real scenario.

3.66 Some of the stakeholders mentioned in their comments that unsold spectrum in various bands should be valued at 50% of previous reserve price in 2016.

3.67 One stakeholder commented that unlike last time in October, 2016 auction, both 2500 MHz and 2300 MHz bands should be treated as separate bands and the price of 2500 MHz band should be different from the price determined for 2300 MHz band.

3.68 The Authority is aware that internationally, various spectrum bands are being administratively allocated as well as auctioned but the valuation of a specific spectrum band in India cannot be directly related to the price realized from the auction of such band in other countries around the world for a variety of reasons. The Authority had previously deliberated on this valuation approach in Para 4.34 of September 2013 Recommendations and Para 3.56 to 3.63 of February, 2014 Recommendations and had taken a view that the valuation of a specific spectrum band in India cannot be compared with price realized from the auction of such band in other countries.

3.69 The Authority has examined the comments of the stakeholders; most of the stakeholders are in favour of use of auctioned determined price of last auction for arriving at value of this band but against the indexation of auctioned determined price. Some stakeholders have stated that the technical efficiency factor of some other spectrum band should not be used to arrive at the value of this spectrum band.

3.70 Due to non-availability of any financial or non-financial information for estimating the valuation of 2300 MHz spectrum and considering that market revealed prices as the best indicative value of spectrum, it would be appropriate to use market revealed prices of last auction held in 2016 for valuation of this band. The Authority is of the considered opinion that October, 2016 auctioned determined prices duly indexed (with MCLR) can be used as reserve price for those LSAs where spectrum was sold. In the LSAs where spectrum was offered for sale but could not be sold, the Authority is of the opinion that reserve price recommended for 2016 auctions should be taken as reserve Price for current auction without indexation.

3.71 Keeping in view the comments of stakeholders and above factors, **the Authority recommends that the reserve price of 2300 MHz spectrum band should be equal to-**

(i) October, 2016 auctioned determined price duly indexed with MCLR for those LSAs where auction have taken place in October, 2016; and

(ii) Last recommended Reserve Price in the LSAs where spectrum was offered but could not be sold in October, 2016 auction without indexation.

Accordingly, the recommended reserve price of 2300 MHz spectrum band for each LSA is tabulated below:

RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2300 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	163.94	164
Mumbai	Metro	167.38	167
Kolkata	Metro	37.83	38
Andhra Pradesh	A	78.35	78
Gujarat	A	70.15	70
Karnataka	A	112.35	112
Maharashtra	A	72.29	72
Tamil Nadu	A	151.33	151
Haryana	B	8.00	8
Kerala	B	20.14	20
Madhya Pradesh	B	9.40	9
Punjab	B	21.00	21
Rajasthan	B	6.00	6
U. P. (East)	B	9.00	9
U.P. (West)	B	12.00	12
West Bengal	B	5.73	6
Assam	C	2.29	2

Bihar	C	7.05	7
Himachal Pradesh	C	1.15	1
Jammu & Kashmir	C	1.00	1
North East	C	1.15	1
Orissa	C	4.59	5

VALUATION AND RESERVE PRICE OF 2500 MHz SPECTRUM BAND

3.72 The spectrum in 2500 MHz band had been auctioned for the first time in October 2016 auction. In this auction, spectrum was offered for bidding in all 22 LSAs. However, spectrum could be sold in 20 LSAs at the reserve prices only. It is pertinent to mention here that the commercial operations are yet to start in this band. Previously, DoT has allotted one block in the 2500 MHz spectrum to the PSUs viz., BSNL and MTNL at a price equal to auction determined price of 2300 MHz band in 2010 auction. Like a few other spectrum bands that are proposed for auction, in this band also, there is little data available with regard to revenue, investment and cost to form a basis for the valuation.

3.73 Based on the physics of frequency spectrum, higher spectrum band does not travel farther and requires additional cell sites / towers deployment to gain equivalent levels of coverage compared to lower frequency bands.

3.74 Considering the fact that no financial and non-financial information pertaining to 2500 MHz spectrum band is available and DoT has already equated value of this band to value of 2300 MHz band discovered in 2010 auction while assigning one block to BSNL/MTNL, the Authority in its recommendations of January, 2016 had recommended that the reserve price of 2500 MHz spectrum be equal to the recommended reserve price of 2300 MHz. Keeping in view

above, following question was posed for seeking the comments of the stakeholders:

Q.13.Whether the valuation of 2500 MHz spectrum should be equal to value of similarly placed spectrum band? If no, then which alternative method should be used for its valuation? Please justify your response with rationale and supporting documents.

3.75 In their responses, majority of the stakeholders were of the view that market determined price of spectrum in October, 2016 be used for arriving at the valuation of 2500 MHz band and wherever the spectrum remained unsold in various bands, the valuation may be set at 50-80% of reserve price of the auction held in October 2016. Few stakeholders commented that reserve price of these spectrum bands be kept at 50% or lower of the last determined price to promote active participation and bidding.

3.76 One of the stakeholders was of the view that the prices discovered in last auction should be taken as the valuation of spectrum for the upcoming auction.

3.77 Some of the stakeholders were of the view that the valuation of the 2500 MHz spectrum should be equal to value of similarly placed spectrum band such as 2300 MHz band.

3.78 However, one of the stakeholders was against considering reserve price for next auction and one other stakeholder suggested that 2300 MHz band and 2500 MHz band be treated separately and further stated that circles where all of the 2500 MHz spectrum remained unsold, there the valuation should be cut by 50%; circles where spectrum remained unsold at reserve price there the valuation should be cut by 30%.

3.79 The Authority has examined the comments of stakeholders, other relevant facts and its past recommendations[39] to equate the reserve price of 2500 MHz spectrum band with the reserve price of 2300 MHz spectrum band, in a situation where TRAI had no data or auction determined price for this band. The only fact available with the Authority was that DOT had allocated 2500 MHz spectrum band to its PSUs in 2010-11 at auction determined prices of 2300 MHz spectrum band in 2010 auction. In October 2016 auction, the 2500 MHz spectrum was offered for sale and it was sold only in 20 LSAs at reserve price. Considering the fact that now auction determined prices are available for this spectrum band in 20 LSAs and the approach is to use the auction determined prices wherever available, the Authority is of the considered opinion that October, 2016 auctioned determined price of 2500 MHz spectrum band duly indexed with MCLR be used in LSAs where spectrum was sold. In other LSAs, where due to non participation of the bidders, the reserve price did not go through the price discovery, in such LSAs reserve price recommended for October, 2016 auction be taken as Reserve Price for the forthcoming auction, as per past practice.

3.80 Keeping in view the comments of stakeholders and above factors, **the Authority recommends that the reserve price of 2500 MHz spectrum band-**

(i) Should be equal to October, 2016 auctioned determined price duly indexed with MCLR for those LSAs where auction have taken place in October, 2016; and

(ii) Last recommended Reserve Price in the LSAs where spectrum was offered but could not be sold in October, 2016 auction.

[39] TRAI spectrum recommendation of January, 2016

Accordingly, the recommended reserve price of 2500 MHz spectrum band for each LSA is tabulated below:

RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2500 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	163.94	164
Mumbai	Metro	167.38	167
Kolkata	Metro	37.83	38
Andhra Pradesh	A	77.96	78
Gujarat	A	44.71	45
Karnataka	A	98.00	98
Maharashtra	A	66.49	66
Tamil Nadu	A	132.00	132
Punjab	B	24.07	24
Bihar	C	6.88	7
Himachal Pradesh	C	1.15	1
Jammu & Kashmir	C	1.15	1

VALUATION AND RESERVE PRICE OF 700 MHz SPECTRUM

3.81 It would be prudent to briefly look at the recent developments and other facts related to this spectrum band in addition to the views of the stakeholders to arrive at appropriate recommendations.

3.82 The 700 MHz band is being used worldwide for deployment of 4G and evolution of 5G services due to its excellent propagation characteristics and therefore it is one of the most sought after band for deployment of LTE. The 700 MHz spectrum band is a much lower band of spectrum. The frequencies of lower spectrum band travels farther and provide enhanced indoor coverage compared to higher

frequencies where additional cell sites/ towers would be required to be deployed to gain equivalent levels of coverage. The 700 MHz band is a liberalized spectrum band; therefore it can be used for deployment of any technology in India.

3.83 Due to better propagation characteristics and higher penetration inside the high rise buildings and wider coverage, the deployment of 700 MHz spectrum band not only significantly saves the capital expenditure (CAPEX) involved in making the network live but also has the potential to save the operating expenditure (OPEX) for maintenance of comparatively lesser number of cell sites and towers required for setting up the LTE networks in comparison to deployment for higher spectrum bands.

3.84 Unlike many other spectrum bands, neither the auction determined value nor the financial or non-financial information, is available for determination of this spectrum band as this spectrum band was not allocated and hence currently not in use in India for IMT service. In the absence of relevant data for determining the value of such spectrum band, the Authority, in the past, has used relative technical efficiency factor of other spectrum band to determine the value of 700 MHz spectrum band but there was no taker for this spectrum band in October, 2016 auction. Since then, the Authority has collected more information about this band but the data is still insufficient to carry out a detailed valuation exercise. Accordingly, following questions were raised in the consultation paper for consultation with the stakeholders:

Q.9 Whether the value of 700 MHz spectrum should be derived by relating it to value of other bands by using technical efficiency factor? If yes, with which spectrum band this band be related and what efficiency factor or formula should be used? Please justify your views with supporting documents.

Q.10 Else, what valuation approach should be adopted for the valuation of 700 MHz spectrum band? Please support your valuation approach with detailed methodology and related assumptions.

3.85 In response to these questions, some of the stakeholders commented that while arriving at the valuation of the spectrum band, there are number of factors that are relevant whilst looking at the reserve price for any spectrum band such as the propagation characteristics, the various technologies that can be deployed in the band and the eco-system that exists or is being evolved etc.

3.86 Few stakeholders were of the view that it was important to balance the need for the spectrum with the development of the local ecosystem of network and devices for that band. They stated that there was still a long way to go before the eco-system in this band could fully develop like other commercial bands and it would take time for the 700 MHz market to mature and provide affordable devices in this spectrum range for the subscribers. It has been further stated that any untimely auction of spectrum in 700 MHz band may accrue revenue to the Government, but the commercial exploitation of such scarce resource for the larger interest of the society may be permanently impaired if the operators are forced to bid for such auction ahead of its commercial viability.

3.87 Other stakeholders were of the view that it was important to ensure that auctions are recommended to be held at an appropriate time to ensure adequate participation.

3.88 One of the stakeholders was of the view that whilst revising the valuation for the 700 MHz band, not only consider the international benchmarks, but also the financial deterioration and the exits/consolidations that are taking place in the sector.

3.89 Some of the stakeholders stated that the 700 MHz spectrum has same technical efficiency with respect to coverage & capacity as 800 MHz band. Both the spectrum bands can be used for LTE & LTE advanced services. 800 MHz band is better as compared to 700 MHz and 800 MHz spectrum band is being used for multiple technologies –CDMA, 3G & LTE. On the other hand, 700MHz could only be used for 4G/ LTE network. No antenna change is required in case of evolution of 800 MHz band from legacy networks to LTE, while 700 MHz would need completely the new set of antenna ports.

3.90 Few of the stakeholders were of the view that the valuation of 700 MHz spectrum band can be arrived from the other spectrum bands having similar propagation characteristics/ technical efficiency factor such as 800 MHz, 900 MHz bands and stated that developments in both 700 and 800 MHz bands have been towards 4G technologies. Therefore, the value of 700 MHz band should be equal to 800 MHz.

3.91 One stakeholder stated that only technical efficiency should not be the parameter for deciding the valuation of any spectrum band as well as 700 MHz Band. Other parameter like demand for a particular band, financial condition/ revenue of telecom sector, availability of eco-system of particular band should also be considered in deciding the valuation of any spectrum band.

3.92 The Authority has carefully examined the comments received from stakeholders. From the comments of the stakeholders it emerges that there is a wide variation among views of stakeholders on the valuation of 700 MHz band also known as APT 700 band. Their suggestions primarily appear to be driven by the state of development of the ecosystem of network and devices for 700 MHz band. However, there is a broad consensus among the stakeholders' about the better propagation characteristics or the technical efficiency factor of 700 MHz as compared to other spectrum bands and its suitability for

LTE/ LTE advance technology. Some of the stakeholders had concerns about issues like demand of particular band, financial condition of telecom sector, availability of eco-system of particular band etc.

3.93 As mentioned in Chapter II, 700 MHz band is considered a suitable band for LTE deployment around the world due to its efficiency and higher penetration inside buildings. LTE device eco-system is developing fast in this band. Adoption of the APT700 MHz band plan for LTE network deployments is taking place in different markets across the globe. According to GSA report "GSA Snapshot: LTE in APT700 Spectrum Global Status" published in February 2018, 44 operators had launched commercial services using APT 700 (band 28) or in compatible European bands (CEPT 700). A growing number of manufacturers already offer smart phones, tablets and customer premises equipment (CPE) for this band now: Acer, Apple, Asus, Foxconn/InFocus, Fujitsu, HTC, Huawei, LG, Motorola, Samsung, Sierra Wireless, Sony, TCL/Alcatel and ZTE. Major infrastructure providers such as Ericsson, Huawei and Nokia, among others, now offer equipment for APT 700 MHz. Over 50 countries and territories have allocated, or committed to APT 700 FDD (band 28), or compatible European bands, for LTE system deployments. Thus, the ecosystem in this band is maturing fast globally and now there is a greater acceptance of APT 700 band as compared to 2016.

3.94 APT 700 MHz band will be extremely useful as an additional band for providing LTE and 4G services in the country particularly in rural areas for widespread coverage. Better access to education, improved healthcare and financial inclusion are all likely to result from widespread access to high-speed mobile broadband. After considering the comments of stakeholders and developments as mentioned above, the Authority is of the view that auction of APT 700 MHz band should be done as there have been considerable improvement in the device

ecosystem and technologies for this band. The Authority is of the considered opinion that allocation of APT 700 MHz would bring the needed momentum and attractiveness among the equipment manufacturers/vendors for development of ecosystem of APT 700 band in India. Therefore, the Authority is of the opinion that auction of APT 700 MHz spectrum should be undertaken alongwith other spectrum bands in the forthcoming auction.

3.95 In the year 2012, the Authority, inter-alia, recommended reserve price of spectrum in 700 MHz band. For the purpose of arriving at reserve price of spectrum in 700 MHz band, the Authority, in its recommendations on 'Auction of Spectrum' dated 23rd April 2012, referred to an OFCOM consultation report (Jan 2012), and recommended that the reserve price should be around 4 times that of 1800 MHz band. The Authority further recommended that the auction of spectrum in 700 MHz band may be carried out at a later date, preferably in 2014 as and when the ecosystem for LTE in the 700 MHz is reasonably developed, so as to be able to realize the full market value of the spectrum. However, the 700 MHz spectrum band was not put to auction till 2016.

3.96 Subsequently, in its Recommendations on 'Valuation and Reserve Price of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz Bands' dated 27th January, 2016, the Authority, inter-alia, stated that "as was recommended by the Authority in April 2012, the auction of 700 MHz band, the reserve price should be around four times that of 1800 MHz band and therefore, the same can be used for valuation of 700 MHz band as market revealed prices for 1800 MHz band are available. In absence of any other better approach, the same is being followed in the valuation of 700 MHz band." Accordingly, in the auction held in October 2016, 770 MHz (35 MHz in each LSA- 713-748 MHz for uplink and 768-803 MHz for downlink) paired spectrum in the 700

MHz band was put to auction. No bid was received for the spectrum in this band. Therefore, entire spectrum (770 MHz) remained unsold.

3.97 It has been noted that since the year 2012, considerable change has taken place in the global ecosystem in this band as well as in the Indian Telecom Industry. Since the last two years, the telecom industry has been undergoing consolidation as some of the TSPs have filed for merger of their companies/ licences, while a few licensees have traded their entire spectrum and closed their services.

3.98 As the spectrum in 700 MHz band has already been auctioned in many countries in the past few years, the latest data on the auctioned price of spectrum in 700 MHz band as compared to the auctioned price of spectrum in 1800 MHz in some of the countries are now available and the same are given in the Table below.

Table 3.2

Comparative Statement of Auction Price* Per MHz (in USD)

Country	Month & Year of auction	Country Currency	1800 MHz	700 MHz (800 MHz for Europe)	Ratio
(A)	*(B)*	*(C)*	*(D)*	*(E)*	*(F=E/D)*
Taiwan	OCT, 2013	TWD	656541667	339111111	**0.52**
Serbia	NOV, 2015	Euro	350000	1750000	**5.00**
Turkey	AUG, 2015	Euro	6982441	19048333	**2.73**
Croatia	NOV, 2013	HRK		4800467	**0.53**
	NOV, 2015	HRK	9064103		
Denmark	JUNE, 2012	DKK		12718424	**1.61**
	SEPT, 2016	DKK	7884615		
Germany	NOV,2011	Euro		64002000	**2.66**
	JUNE, 2015	Euro	24050000		
Singapore	SEPT,2013	SGD	16094797		**0.58**
	NOV, 2017	SGD		9400000	

Greece	NOV, 2017	Euro	1831364		**2.81**
	OCT, 2014	Euro		5151210	
Median					**2.14**

** Inflation adjustments have been made based on officially published inflation data from each of these countries*

Source: National Institute of Public Finance and Policy (NIPFP)/ TRAI research

3.99 From the Table given above, it can be seen that there are large variations in the pricing of spectrum in 700 MHz band as compared to 1800 MHz band in various countries. However, it can be seen that though the ratio of pricing of spectrum in 700 MHz band as compared to 1800 MHz band varies from 0.5 to 5.0, the median of these ratios comes out to be around 2.14.

3.100 In one of its studies [40] ,which has also been referred in the consultation paper[41], ZTE has come out with a comparison based on the uplink edge rate from dense urban to rural environments and the coverage radius of a single site utilizing 700MHz, 800MHz, 1.8GHz, 1.9GHz, 2.1GHz, and 2.6GHz as shown in following Table.

Table 3.3

Comparison based on the uplink edge rate and the coverage radius

Morph	**Dense Urban**		**Urban**	**Suburban**	**Rural**
Cell Edge User Throughput	kbps	512	256	128	64
700MHz					
UL Cell Range	km	0.70	1.21	3.37	8.48
Coverage Area	Km2	0.95	2.84	22.16	140.37
800MHz					
UL Cell Range	km	0.63	1.09	3.04	7.65
Coverage Area	Km2	0.78	2.33	18.06	114.22

[40] https://www.gsma.com/spectrum/wp-content/uploads/2013/07/ZTE-LTE-APT-700MHz-Network-White-Paper-ZTE-June-2013.pdf

[41] Consultation Paper on Auction of Spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands.

1.8GHz					
UL Cell Range	km	0.38	0.64	1.67	4.40
Coverage Area	Km2	0.27	0.80	5.42	37.71
1.9GHz					
UL Cell Range	km	0.36	0.61	1.58	4.17
Coverage Area	Km2	0.25	0.72	4.87	33.84
2.1GHz					
UL Cell Range	km	0.32	0.55	1.43	3.77
Coverage Area	Km2	0.21	0.60	4.00	27.69
2.3GHz					
UL Cell Range	km	0.30	0.51	1.31	3.44
Coverage Area	Km2	0.17	0.50	3.35	23.08
2.6GHz					
UL Cell Range	km	0.27	0.45	1.16	3.04
Coverage Area	Km2	0.14	0.40	2.63	18.06

3.101 From the above Table, it is clear that the technical efficiency factor in respect of UL Cell range for 700 MHz band with respect to 1800 MHz band is 1.84 which is very near to a factor of 2(two).

3.102 It has been noted that in a whitepaper[42] released by Huawei in December 2016 on LTE APT 700 deployment, the propagation characteristics of different bands have been compared. The higher frequency bands (>1GHz) have larger propagation loss and low bands such as 700 MHz and 800 MHz bands have lower propagation losses. Huawei has compared APT700 band with several other LTE bands adopting Hata model, which is divided into Okumura-Hata model and Cost231-Hata model, to calculate the propagation loss. Okumura-Hata model is suitable for spectrum between 150MHz ~ 1500MHz, while Cost231-Hata model is used for spectrum above 1500MHz. It has been observed that a single site coverage area using 700MHz band is almost 2 times larger than 1800 MHz band.

[42] APT 700 LTE whitepaper (Q4-2016) Issue, https://gsacom.com/paper/apt700-white-paper-huawei/

3.103 Para 1.4 (Chapter-I) of these recommendations, discusses the large quantity of unsold spectrum in 2016 spectrum Auctions (770 MHz in 700 MHz band, 58.75 MHz in 800 MHz band, 9.4 MHz in 900 MHz band, 46.8 MHz in 1800 MHz band, 275 MHz in 2100 MHz band, 230 MHz (unpaired) in 2500 MHz band).Previous chapters also mention about the additional spectrum that is likely to be available in some of the bands due to spectrum re-farming and harmonization process as well as due to expiry of licenses. In addition, a new spectrum band from 3300 MHz to 3600 MHz is also being included in the list of spectrum bands being recommended for auction. The higher frequency bands are used by the service providers mostly for capacity purpose and lower frequency bands are used mostly for coverage purpose. Therefore, an optimum combination of such higher and lower frequency bands is desirable to have an optimum mix of capacity and coverage. Therefore, the cost of spectrum has to be reasonable to provide the desired socio-economic benefits to all the sectors of the society.

3.104 At the time of previous auctions on an average there were 8 to 10 TSPs, making India as one of the most competitive Telecom market. However, in last two years the Telecom Industry has been undergoing consolidation phase as some of TSPs have filed merger of their companies/licenses. With the result, now the no of TSPs is reduced to practically four. Further, consequent upon issue of spectrum trading and sharing guidelines [43], in past two years secondary spectrum trading and sharing market is evolving fast. These two developments have increased the spectrum availability with existing leading TSPs manifold.

3.105 Accordingly, based on the technical efficiency factors mentioned in preceding paras and other developments discussed in preceding

[43] http://www.dot.gov.in/accessservices/guidelines-spectrum-sharing

paras, the Authority is of the opinion that the reserve price of spectrum in 700 MHz band should be two times that of 1800 MHz band.

3.106 **Therefore, the Authority recommends that reserve price of 700 MHz band should be equal to 2 times of reserve price of 1800 MHz spectrum band. Accordingly, the recommended reserve price of 700 MHz spectrum band for each LSA is as under: -**

RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 700 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	914.84	915
Mumbai	Metro	1121.65	1122
Kolkata	Metro	346.56	347
Andhra Pradesh	A	557.16	557
Gujarat	A	545.69	546
Karnataka	A	218.96	219
Maharashtra	A	729.12	729
Tamil Nadu	A	199.24	199
Haryana	B	113.04	113
Kerala	B	190.30	190
Madhya Pradesh	B	190.30	190
Punjab	B	176.55	177
Rajasthan	B	210.71	211
U. P. (East)	B	305.29	305
U.P. (West)	B	229.97	230
West Bengal	B	105.47	105
Assam	C	91.71	92
Bihar	C	175.24	175

Himachal Pradesh	C	36.69	37
Jammu & Kashmir	C	29.81	30
North East	C	25.22	25
Orissa	C	54.04	54

VALUATION AND RESERVE PRICE OF 3300-3400/3400-3600 MHz SPECTRUM BANDS

3.107 In the previous chapter of these recommendations it has been recommended that the 3300-3400 MHz and the 3400-3600 MHz bands combined together should be treated as one band and termed as 3300-3600 MHz spectrum band. These bands, also called mid-bands, have been identified globally as a 5G pioneer band and have already been assigned in a number of markets including the UK, Japan, Spain, Hungary, Latvia, Slovakia, South Korea and Ireland.

3.108 This spectrum band will play a critical role in the introduction of 5G because of availability of a large amount of spectrum to deliver the high-levels of performance expected from 5G. Further, it has been opined that in comparison to other 5G pioneer bands such as 26 GHz in Europe and 28 GHz in USA, Japan and South Korea, the lower frequency of 3.5GHz band provides better propagation. This characteristic makes it possible to be deployed on existing operators' networks rather than requiring the development of a new and expensive very small cell network.

3.109 Like any other asset, one of the key determinants of the value of 3300-3600 MHz spectrum band will also be, *inter alia*, the relative levels of supply and demand. Paras 3.103 and 3.104 of these recommendations that have already discussed the increased supply of Spectrum and greater availability of spectrum with the TSPs in general are relevant in context of 3300-3600 MHz spectrum band too. The growing demand for spectrum for emerging 4G LTE/LTE

advanced, 5G and IOT technology based services has also been discussed earlier in these recommendations[44].

3.110 The pace at which operators will be able to re-farm existing spectrum holdings from 2G, 3G and 4G to 5G would be another factor affecting the relative levels of supply and demand. The speed of re-farming is in turn affected by the rate at which devices for the new spectrum bands diffuse through the market. One, therefore, has to factor developments in the device ecosystem, the rate of device diffusion and the ability to re-farm in order to value 3.5 GHz spectrum. However, it is not possible to arrive at precise answers to these issues. The Authority, therefore has studied various reports in public domain to arrive at a possible value and reserve price.

3.111 3GPP and the ITU have released standardized bands for wireless networks and these are likely to be expanded / ratified in the forthcoming World Radio-Communication Conference in 2019 (WRC19). 3GPP has standardized Band 42 (3400 MHz to 3600 MHz) and Band 43 (3600 MHz to 3800 MHz) for use by any 3GPP TDD technology. 3GPP in its Release-15 has designated these bands as n77 (3300 MHz – 4200 MHz) and n78 (3300 MHz – 3800 MHz) for 5G New Radio (NR) specifications. Currently, these bands are only used for LTE-A networks. These are relatively new bands and while the infrastructure is generally available, devices are only now becoming available at scale. Some Standard mobile handsets are only available in Band 42 (for example, Apple, Samsung Tab, Sony). It is expected that handsets will become generally commercially available on large scale within 2 to 3 years.

3.112 One of the challenges in valuation for this band is lack of an appropriate revenue forecast because there is a lot of exaggeration associated with 5G and Internet of Things' in the reports in public

[44] Paras 2.21 to 2.28,2.61,2.62 and 3.5 to 3.8 of the current recommendations

domain. One needs to take a very pragmatic and realistic view of the role 5G/IoT is able to play in the ICT value chain and the revenue of the traffic types they are going to generate. Ideally one should be able to differentiate between relative levels of 5G spectrum in their potential for any competitive advantage over the others. In absence of even the standards that are yet to be finalized by the WRC 2019 and the still evolving device ecosystem, the Authority has decided to take a conservative view of the possible revenue resulting out of 5G and IoT considering that most of the projections and scenarios available in public domain are either by manufactures, industry associations and the companies involved in big data and are largely speculations.

3.113 Government of India has indicated launch of 5G in India on a full scale along with other developed nations[45]. The report of the Forum is not available to TRAI at the time of submission of the recommendations. But various other Governments/Regulatory Bodies like U.K., USA, Canada, BEREC, Japan, Korea, Australia etc have also taken steps in this regard. The Authority has studied some of the 5G studies commissioned by Ofcom, ARCEP, ComReg, BEREC, Australia, FCC and "5G for Europe Action Plan" of European Commission (EC).

3.114 In spite of growing momentum towards 5G and IOT, it is very difficult to project an ideal risk return profile for the operators in a 5G band, even though bright revenue growth projections have been made in some reports. Further, there is also a challenge in form of estimating the cost of rolling out a 5G network because the traditional knowledge and methodology no longer apply to 5G Networks.

[45] Ministry of Communications press release dated 26-September-2017 constituting High Level 5G India 2020 Forum http://pib.nic.in/newsite/PrintRelease.aspx?relid=171113

3.115 With regard to DoT's reference for valuation and determination of reserve price of spectrum bands 3300-3400 and 3400-3600 MHz. DoT has stated that the spectrum bands 3300-3400 and 3400-3600 MHz are proposed for providing access services. DoT also stated that for some of the ISPs to whom spectrum has been assigned in this band (3300-3400 MHz), a case for harmonization / vacation of this band is being initiated and it is expected that entire band will be made available for telecom services by the end of this year.

3.116 Again, the valuation of 3300-3400 MHz and 3400-3600 MHz spectrum bands are being put to auction for the first time in India, its valuation is also dependent on the availability of cost, revenue and other financial and non-financial information pertaining to this band. However, unlike the other spectrum bands (800 MHz/900 MHz/1800 MHz/2100 MHz), both financial and non-financial information, is not available in the case of the 3300-3400 MHz and 3400-3600 MHz spectrum bands. Therefore, following question was raised for consultation:

Q.14 Whether the valuation of the 3300-3400 MHz spectrum bands and 3400-3600 MHz spectrum bands should be derived from value of any other spectrum band by using technical efficiency factor? If yes, what rate of efficiency factor should be used? If no, then which alternative method should be used for its valuation? Please justify your response with rationale and supporting documents.

3.117 In response to above question, one of the stakeholders submitted that the factors such as propagation characteristics, technologies which can be deployed and the existing ecosystem should be taken into consideration while arriving at the valuation of the spectrum band.

3.118 Most of the stakeholders are of the view that the reduced coverage of 3300-3400 MHz and 3400-3600 MHz bands as compared to 2300, 2500MHz bands would mean higher capex in the network. Moreover, the ecosystem 3300-3400 MHz and 3400-3600 MHz is yet to develop.

3.119 While few other stakeholders consider that TRAI should use technical efficiency method of determining spectrum value as it seems to be the more appropriate approach. The closest band for which the auction determined value is available is the 2300 MHz / 2500 MHz band.

3.120 Although these bands have been auctioned in other countries but these bands are being auctioned for the first time in India, some of the stakeholders are of the opinion that the Authority may also consider international benchmarks for valuation of these bands. One of the stakeholders is of the view that TRAI should look at international benchmarks in these bands and adjust these for the Indian scenario, by applying purchasing power parity and also keeping in mind the significant financial deterioration of the sector since the last auctions as also the exits/consolidations that are taking place in the sector.

3.121 One stakeholder has suggested for ascertaining value of the 3300-3400 MHz and the 3400-3600 MHz bands based on technical efficiency of these bands vis-à-vis the 2300/2500 MHz band and further stated that TRAI may take in to account the "state of existing ecosystems" and availability of infrastructure in the country, and also the affordability for the consumers as overriding factors in fixing the valuation. The spectrum prices should be rationalized by adopting holistic approach which truly reflects the business potential of the market for that particular band. Maximum Government revenues would be only through growth and not by excessive auction pricing design.

3.122 Some of the stakeholders have stated that these bands require extensive fibre network to have comparable coverage of bands such as in 2.3 GHz or 2.5 GHz and these bands are like Wi-Fi bands which can be predominantly be used for short distance or last mile connectivity etc. The use of spectrum in hotspot locations, i.e. instead of Pan-LSA coverage, will restrict the monetization of spectrum to hotspot locations only. Also, the availability of commercial products/ solutions is expected to be in market from 2020 onwards. This would mean any commercial use of the spectrum would only happen post 3 years of spectrum auction (assuming spectrum auction in FY'18).

3.123 Few of the stakeholders are of the view that considering coverage of the spectrum band compared to other TDD bands such as 2.3 GHz or 2.5 GHz band - reduced coverage would mean higher CAPEX for network rollout and propagation characteristics of 3300- 3400 MHz and 3400-3600 MHz, the valuation of spectrum bands should be 25% of the reserve price of 2300 MHz/ 2500 MHz band.

3.124 After considering the significant challenges in valuing this band and the stakeholders' comments mentioned above, the Authority attempted to relate the valuation of 3.5 GHz with the valuation of other LTE Bands in vogue in India for which market discovered price is available or to use international benchmarking for arriving at valuation of 3300-3600 MHz band. This is discussed in the succeeding paras.

3.125 The most popular LTE band in India and abroad is 1800 MHz band. Availability of recent market discovered prices for this spectrum band in each of the LSAs in India makes it useful for deriving relative value of other bands. The Authority studied the *inter se* technical effectiveness of different spectrum bands and has examined the related technical literature.

3.126 TRAI studied the auctions for information in other jurisdictions to carry out a comparative analysis of spectrum valuation and pricing. After analysis of the Auction of 3300-3600 MHz, in various countries, it is evident that due to lack of adequate comparable data points, international benchmarking may not be appropriate for current valuation exercise for 3300-3600 MHz.

3.127 The Authority has taken into account the ecosystem, devices etc. in these bands and the fact that neither the auction determined value nor the other related information specific to India, is available for determination of value of these spectrum bands.

3.128 In a technical note prepared by NOKIA[46] on "5G Spectrum and Coverage Consideration Aspects", 2018, it has been mentioned that 3.5 GHz band is expected to operate on TDD mode. Coverage from 5G using this band will be limited as it will suffer both due to high propagation loss and TDD mode penalty. As per coverage analysis by NOKIA, 3.5 GHz band TDD coverage will be around 70% lower than the 1800 MHz band FDD coverage. Taking 1800 MHz band as FDD coverage as reference, the 3300-3600 MHz band TDD coverage has been estimated around 30% of the 1800 MHz FDD coverage.

3.129 After analyzing comments and counter comments, Open House Discussion and studying industry reports. the Authority is of the view that the spectrum band 3300MHz to 3600MHz should be treated as a single band of 300 MHz which is expected to operate in TDD Mode. Taking 1800 MHz band FDD coverage as reference, the 3300 MHz-3600 MHz band coverage should be around 30% of the 1800 MHz band FDD Coverage. The Authority is also aware that evolution of 5G and related eco system in this band will still take a few years. The Authority, therefore, in view of the foregoing paragraph recommends a reserve price for 3300-3600 MHz band equivalent to 30% of the

[46] 5G Spectrum and Coverage Consideration Aspects – Technical Note, 2018

reserve price of the 1800 MHz FDD band. However, as 3300-3600 MHz band is unpaired, the reserve price has been calculated accordingly.

3.130 **The Authority recommends that reserve price of 3300-3600 MHz band should be equal 30% of the reserve price of 1800 MHz FDD band. As 3300-3600 MHz band is unpaired, the reserve price has been calculated accordingly. The recommended reserve price of this spectrum band for each LSA is tabulated below:**

RECOMMENDED RESERVE PRICE PER MHz IN 3300-3600 MHz BAND (UNPAIRED)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	68.61	69
Mumbai	Metro	84.12	84
Kolkata	Metro	25.99	26
Andhra Pradesh	A	41.79	42
Gujarat	A	40.93	41
Karnataka	A	16.42	16
Maharashtra	A	54.68	55
Tamil Nadu	A	14.94	15
Haryana	B	8.48	8
Kerala	B	14.27	14
Madhya Pradesh	B	14.27	14
Punjab	B	13.24	13
Rajasthan	B	15.80	16
U. P. (East)	B	22.90	23
U.P. (West)	B	17.25	17
West Bengal	B	7.91	8
Assam	C	6.88	7
Bihar	C	13.14	13
Himachal Pradesh	C	2.75	3

Jammu & Kashmir	C	2.24	2
North East	C	1.89	2
Orissa	C	4.05	4

SPECTRUM USAGE CHARGES

3.131 As per the extant licensing conditions of UASL/ CMTS/UL, the spectrum usage charges (SUC) are levied as a percentage of the Adjusted Gross Revenue (AGR) earned by the spectrum holder. The SUC rate varies (in case of administratively assigned spectrum on slab based rate or mix of administratively assigned spectrum and the spectrum acquired through auction on weighted average rate and the spectrum acquired through auction at certain percentage of AGR) depending on the quantum of spectrum and type of spectrum held by a wireless licensee.

3.132 The Authority has made following recommendation on SUC on 9th September 2013 under "Valuation and Reserve Price of Spectrum" to DoT. These are not restricted to any specific band and are equally applicable to all spectrum bands and type of holdings.

(i) All spectrum allocated through auction should henceforth be charged at a flat rate. The Authority also recommends that spectrum acquired through auction or trading or on which a TSP has paid the prescribed market value to the Government should not be added to any existing spectrum holdings for determining the applicable slab rate. This will also apply to spectrum allocated in the auctions held in November 2012 and March 2013.

(ii) The SUC for all auctioned spectrum should be at a flat rate of 3% of AGR of wireless services. This will come into effect from 1st April, 2014.

(iii) The SUC rate for BWA spectrum should also be fixed at 3% where services are provided under CMTS/UASL/UL (AS)/UL.

(iv) The highest slab rate of SUC may be brought down to 5% of AGR with effect from 1st April, 2014.

3.133 The aforementioned Recommendations on Spectrum Usage Charges for all the spectrum bands were reiterated by the Authority in its last recommendation of 27th January 2016 on 'Valuation and Reserve Price of Spectrum' and following clarification dated 12th July 2016 on the reference back of DoT dated 24th June 2016.

3.134 Since there is no change in the Authority's stand on the levy of SUC, **the Authority once again reiterates its Recommendations of 27th January, 2016 and its subsequent clarification dated 12th July 2016 on the reference back of DoT dated 24th June 2016 on Spectrum Usage Charges (SUC). The SUC shall be applicable for all spectrum bands including 700 MHz and 3300-3600 MHz.**

CHAPTER-IV: SUMMARY OF RECOMMENDATIONS

4.1 The Authority recommends that

(a) Entire available spectrum should be put to auction in the forthcoming auction.

b) In the era of administrative assignment of spectrum, the spectrum was unliberalized i.e. not technology neutral and was assigned either to provide GSM services or CDMA services. In case of closure of GSM or CDMA services, a TSP cannot be allowed to hold the administratively assigned spectrum for which it has not paid the market determined price. Any such spectrum lying with TSPs should be taken back and put to auction in the forthcoming auction.

c) DoT should carry out harmonization exercise in West Bengal (WB) LSA in 800 MHz band so that entire available spectrum can be made contiguous and put to auction in the forthcoming auction.

d) DoT should carry out refarming and harmonization exercise in the 2300 MHz band at the earliest and ensure that entire spectrum that is available for commercial use is put to auction so as to avoid a situation where precious spectrum in this band remains unutilized resulting in revenue loss to the Government.

e) Barring the specific locations or districts where ISRO is using the 25 MHz (3400 MHz - 3425 MHz) of spectrum, the entire spectrum from 3300 MHz to 3600 MHz should be made available for access services and should be included in the forthcoming auction.

[Para 2.38]

4.2 The Authority recommends that in case of 900 MHz band, the new entrant should be allowed to bid for 5 MHz if at least one chunk of contiguous 5 MHz is available, else the minimum block size should be kept as 0.6 MHz. Barring this, principles based on which all the provisions of block size and minimum quantity for bidding were specified in the NIA of September 2016, should be retained. It leads to the following table:

Block size and minimum spectrum for bidding

Spectrum Band	Block Size (MHz)	Minimum amount of spectrum that a bidder is required to bid for	
		Existing licensees (MHz)	New Entrants (MHz)
700 MHz	5 (paired)	NA	5
800 MHz	1.25 (Paired)	1.25	5/ 3.75 (if only 3.75 MHz spectrum is available)/2.5 (if only 2.5 MHz spectrum is available)/ 1.25 (if only 1.25 MHz spectrum is available)
900 MHz	0.20 (paired)	0.6	5 MHz, if at least one chunk of contiguous 5 MHz is available; else, 0.6 MHz
1800 MHz	0.20 (paired)	0.6	5 MHz, if at least one chunk of contiguous 5 MHz is available; else, 0.6 MHz
2100 MHz	5 (paired)	5	5
2300 MHz	10 (unpaired)	10	10
2500 MHz	10 (unpaired)	10	10

[Para 2.45]

4.3 The Authority recommends that

a) 3300-3600 MHz should be auctioned as a single band and TDD based frequency arrangement should be adopted for this band.

b) Spectrum in 3300-3600 MHz band should be put to auction in the block size of 20 MHz. To avoid monopolization of

this band, there should be limit of 100 MHz per bidder. Since the TSPs are allowed to trade their partial or complete spectrum holding to another TSP, the limit of 100 MHz spectrum in 3300-3600 MHz band, shall also apply for spectrum trading.

c) In case a TSP acquires more than one block, the entire spectrum should be assigned to it in contiguous form.

d) In case a TSP acquires spectrum in 3300-3600 MHz band in more than one LSA, same frequency spots should be assigned to it in all those LSAs.

[Para 2.70]

4.4 The Authority recommends that the roll-out obligations prescribed for the auctions held in 2016 for 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, and 2500 MHz may be continued in the forthcoming auction. [Para 2.80]

4.5 The Authority recommends that no roll out obligations should be mandated for spectrum in 3300-3600 MHz band. However, to avoid any misuse of not mandating any roll-out obligations, the lock-in period for spectrum in this band for becoming eligible for spectrum trading should be 5 years instead of 2 years. [Para 2.91]

4.6 The Authority recommends that the revised provisions of spectrum cap (i.e. 35% Overall cap and a Cap of 50% on the combined spectrum holding in the sub-1 GHz bands) should be extended to 3300-3600 MHz band also. Additionally, in 3300-3600 MHz band, there should be a spectrum holding cap of 100 MHz per licensee. [Para 2.100]

4.7 The Authority recommends that there is an urgent need of audit of all allocated spectrum both commercial as well as spectrum allocated to various PSUs/ Government organizations. This should be done by an independent agency on a regular basis. [Para 2.106]

4.8 The Authority recommends that the auction determined price of 800 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz spectrum bands auctioned in last two years, duly indexed with MCLR is to be taken as one of the possible values in the respective spectrum bands in the present spectrum valuation exercise. [Para 3.29]

4.9 The Authority recommends that the average expected valuation of spectrum band in a LSA should be the higher of the two figures – (i) average expected valuation of that band based on simple mean or (ii) the auction determined price of October 2016 (duly indexed) [Para 3.50]

4.10 The Authority recommends that the reserve price for North East and Jammu & Kashmir LSAs in 800 MHz band, 900 MHz band, 1800 MHz band and 2100 MHz band may be fixed at a discount of 50% on the reserve price. The discount in North East and Jammu & Kashmir LSAs will also be given while arriving at reserve prices of other spectrum bands. [Para 3.56]

4.11 The Authority recommends that the reserve price for 800 MHz, 900 MHz, 1800 MHz and 2100 MHz bands

(i) should be higher of the two figures – 80% of the average valuation of spectrum band in the LSA or the price realised in the October 2016 auction (duly indexed);

(ii) in LSAs where no spectrum was offered in October 2016

auctions, reserve price should be 80% of average valuation; and

(iii) in LSAs where spectrum was offered in October 2016 auction but remained entirely unsold, the reserve price should be lower of the figures – 80% of average valuation or the reserve price as fixed in October 2016 auction.

[Para 3.59]

4.12 The recommended reserve price of 800 MHz, 900 MHz, 1800 MHz and 2100 MHz spectrum bands for each LSA is tabulated below:

RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 800 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	640.39	640
Mumbai	Metro	727.00	727
Kolkata	Metro	160.00	160
Andhra Pradesh	A	390.01	390
Gujarat	A	384.56	385
Karnataka	A	191.59	192
Maharashtra	A	510.38	510
Tamil Nadu	A	174.34	174
Haryana	B	57.00	57
Kerala	B	157.06	157
Madhya Pradesh	B	142.78	143
Punjab	B	156.70	157
Rajasthan	B	265.94	266
U. P. (East)	B	251.06	251
U.P. (West)	B	160.98	161

West Bengal	B	73.83	74
Bihar	C	136.00	136
Himachal Pradesh	C	24.00	24
Orissa	C	47.28	47

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)
IN 900 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Gujarat	A	372.77	373
Karnataka	A	237.97	238
Tamil Nadu	A	234.51	235
Haryana	B	101.97	102
U. P. (East)	B	261.54	262
U.P. (West)	B	210.83	211
Bihar	C	200.91	201

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)
IN 1800 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	457.42	457
Mumbai	Metro	560.82	561
Kolkata	Metro	173.28	173
Andhra Pradesh	A	278.58	279
Gujarat	A	272.85	273
Karnataka	A	109.48	109
Maharashtra	A	364.56	365
Tamil Nadu	A	99.62	100
Haryana	B	56.52	57
Kerala	B	95.15	95

Madhya Pradesh	B	95.15	95
Punjab	B	88.27	88
Rajasthan	B	105.36	105
U. P. (East)	B	152.64	153
U.P. (West)	B	114.99	115
West Bengal	B	52.73	53
Assam	C	45.86	46
Bihar	C	87.62	88
Himachal Pradesh	C	18.34	18
Jammu & Kashmir	C	14.90	15
North East	C	12.61	13
Orissa	C	27.02	27

RECOMMENDED RESERVE PRICE PER MHz (PAIRED)
IN 2100 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	635.11	635
Mumbai	Metro	528.50	528
Kolkata	Metro	115.06	115
Andhra Pradesh	A	184.98	185
Gujarat	A	181.17	181
Karnataka	A	90.87	91
Maharashtra	A	390.93	391
Tamil Nadu	A	394.37	394
Haryana	B	63.05	63
Kerala	B	202.91	203
Madhya Pradesh	B	67.72	68
Punjab	B	104.32	104
U. P. (East)	B	126.11	126
U.P. (West)	B	76.35	76
West Bengal	B	35.02	35
Assam	C	30.45	30

Bihar	C	98.59	99
Himachal Pradesh	C	12.18	12
Jammu & Kashmir	C	12.61	13
North East	C	6.00	6
Orissa	C	43.56	44

[Para 3.61]

4.13 The Authority recommends that the reserve price of 2300 MHz spectrum band should be equal to-

(i) October, 2016 auctioned determined price duly indexed with MCLR for those LSAs where auction have taken place in October, 2016; and

(ii) Last recommended Reserve Price in the LSAs where spectrum was offered but could not be sold in October, 2016 auction without indexation.

Accordingly, the recommended reserve price of 2300 MHz spectrum band for each LSA is tabulated below:

RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED)

IN 2300 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	163.94	164
Mumbai	Metro	167.38	167
Kolkata	Metro	37.83	38
Andhra Pradesh	A	78.35	78
Gujarat	A	70.15	70
Karnataka	A	112.35	112
Maharashtra	A	72.29	72

Tamil Nadu	A	151.33	151
Haryana	B	8.00	8
Kerala	B	20.14	20
Madhya Pradesh	B	9.40	9
Punjab	B	21.00	21
Rajasthan	B	6.00	6
U. P. (East)	B	9.00	9
U.P. (West)	B	12.00	12
West Bengal	B	5.73	6
Assam	C	2.29	2
Bihar	C	7.05	7
Himachal Pradesh	C	1.15	1
Jammu & Kashmir	C	1.00	1
North East	C	1.15	1
Orissa	C	4.59	5

[Para 3.71]

4.14 The Authority recommends that the reserve price of 2500 MHz spectrum band-

(i) Should be equal to October, 2016 auctioned determined price duly indexed with MCLR for those LSAs where auction have taken place in October, 2016; and

(ii) Last recommended Reserve Price in the LSAs where spectrum was offered but could not be sold in October, 2016 auction.

Accordingly, the recommended reserve price of 2500 MHz spectrum band for each LSA is tabulated below:

RECOMMENDED RESERVE PRICE PER MHz (UNPAIRED) IN 2500 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	163.94	164
Mumbai	Metro	167.38	167
Kolkata	Metro	37.83	38
Andhra Pradesh	A	77.96	78
Gujarat	A	44.71	45
Karnataka	A	98.00	98
Maharashtra	A	66.49	66
Tamil Nadu	A	132.00	132
Punjab	B	24.07	24
Bihar	C	6.88	7
Himachal Pradesh	C	1.15	1
Jammu & Kashmir	C	1.15	1

[Para 3.80]

4.15 The Authority recommends that reserve price of 700 MHz band should be equal to 2 times of reserve price of 1800 MHz spectrum band. Accordingly, the recommended reserve price of 700 MHz spectrum band for each LSA is as under:

RECOMMENDED RESERVE PRICE PER MHz (PAIRED) IN 700 MHz BAND

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	914.84	915
Mumbai	Metro	1121.65	1122
Kolkata	Metro	346.56	347
Andhra Pradesh	A	557.16	557

Gujarat	A	545.69	546
Karnataka	A	218.96	219
Maharashtra	A	729.12	729
Tamil Nadu	A	199.24	199
Haryana	B	113.04	113
Kerala	B	190.30	190
Madhya Pradesh	B	190.30	190
Punjab	B	176.55	177
Rajasthan	B	210.71	211
U. P. (East)	B	305.29	305
U.P. (West)	B	229.97	230
West Bengal	B	105.47	105
Assam	C	91.71	92
Bihar	C	175.24	175
Himachal Pradesh	C	36.69	37
Jammu & Kashmir	C	29.81	30
North East	C	25.22	25
Orissa	C	54.04	54

[Para 3.106]

4.16 The Authority recommends that reserve price of 3300-3600 MHz band should be equal 30% of the reserve price of 1800 MHz FDD band. As 3300-3600 MHz band is unpaired, the reserve price has been calculated accordingly. The recommended reserve price of this spectrum band for each LSA is tabulated below:

RECOMMENDED RESERVE PRICE PER MHz

IN 3300-3600 MHz BAND (UNPAIRED)

(Rs. in crore)

(1)	(2)	(3)	(4)
LSA	**Category**	**Reserve Price (as calculated)**	**Recommended Reserve Price (Rounded off)**
Delhi	Metro	68.61	69
Mumbai	Metro	84.12	84
Kolkata	Metro	25.99	26
Andhra Pradesh	A	41.79	42
Gujarat	A	40.93	41
Karnataka	A	16.42	16
Maharashtra	A	54.68	55
Tamil Nadu	A	14.94	15
Haryana	B	8.48	8
Kerala	B	14.27	14
Madhya Pradesh	B	14.27	14
Punjab	B	13.24	13
Rajasthan	B	15.80	16
U. P. (East)	B	22.90	23
U.P. (West)	B	17.25	17
West Bengal	B	7.91	8
Assam	C	6.88	7
Bihar	C	13.14	13
Himachal Pradesh	C	2.75	3
Jammu & Kashmir	C	2.24	2
North East	C	1.89	2
Orissa	C	4.05	4

[Para 3.130]

4.17 The Authority once again reiterates its Recommendations of 27th January, 2016 and its subsequent clarification dated 12th July 2016 on the reference back of DoT dated 24th June 2016 on

Spectrum Usage Charges (SUC). The SUC shall be applicable for all spectrum bands including 700 MHz and 3300-3600 MHz. [Para 3.134]

Annexure 1.1

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning and Coordination(WPC) Wing
Sanchar Bhawan, 20, Ashoka Road, New Delhi-110001

No. L-14006/01/2017-NTG Dated: 19.04.2017

To,

The Secretary
Telecom Regulatory Authority of India
MahanagarDoorsancharBhawan
Jawahar Lal Nehru Marg (Old Minto Road)
New Delhi-110002.

Subject: TRAI Recommendations on the Reserve Price for auction of right to use spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands.

Sir,

Government of India is planning to auction of right to use aforesaid bands in the next auction likely to be held this year (2017). The status of availability of spectrum in these bands is as under:-

2. **700 MHz Band:**

2.1 TRAI had made its first recommendation on the reserve price and other related issues for 700 MHz band (along with other bands) in April 2012. Thereafter, band plan for 700 MHz was recommended by TRAI in March 2013.

2.2 DOT made another reference to TRAI to give fresh recommendations on the reserve price and other related issues for 700 MHz band considering the development took place Since April 2012. TRAI gave its recommendations on the reserve price and other related issues for 700 MHz band (along with other bands) on 27th January 2016.

2.3 TRAI in its recommendation has suggested that the reserve price of 700 MHz should be 4 times of 1800 MHz. It was observed by DOT that the TRAI recommended Reserve Price of 700 MHz band is lower than that recommended for 900 MHz for UP (E), UP (W) and Bihar service areas. Similarly, the recommended Reserve Price of 700 MHz band for MP is lower than that recommended for Reserve Price of 800 MHz band.

2.3.1. DOT made a back reference vide letter dated 1st April 2016 and pointed out above observation and mentioned that valuation based only on technical efficiency with other bands will not be correct approach. As it denotes all other factors i.e. development stage of ecosystem, market preference towards any particular band,

7622/19.4.17

timing of auction, etc., technical efficiency based evaluation can be one of the possible valuation but not the only one. The market revealed value and the trends it a better indicator of value placed to the spectrum. TRAI has also not indicated whether the various factors as indicated by it or valuation has been taken into consideration while arriving the reserve in 700 MHz band as 4 times of 1800 MHz band.

2.3.2. It was also pointed out that as far as propagation characteristics are concerned, it is more near to 800/900 MHz and the LTE (FDD) is available only in 42 countries.

2.3.3. TRAI vide aforesaid reference, was also requested to reconsider whether all available spectrum in 700 MHz band be put to auction or the spectrum of 35+35 MHz be split in two phases i.e. 20 + 20 MHz in first phase and 15+15 MHz in second phase also.

2.4 In response, TRAI observed that in the case of 700 MHz band which is being auctioned for the first time, the Authority did not have any historical data – financial as well as non-financial relating to this band. There is no denying the fact that technical propagation characteristic wise 700 MHz is nearer to 800/900 MHz band than 1800 MHz band. Moreover, it is also a fact that as per international trends 700 MHz band will be primarily used for LTE technology and presently 1800 MHz is the most deployed band for LTE technology. Therefore, the Authority has decided to benchmark the reserve price of 700 MHz with reference to 1800 MHz band and not 800/900 MHz band. In view of the above and keeping in view its recommendations of April 2012, the Authority has recommended the reserve price of 700 MHz as four times the 1800 MHz band. As it has not benchmarked reserve price of 700 MHz band with reference to either 800 or 900 MHz, therefore the contention of DOT that in some LSAs the recommended reserve price is lower than the reserve price of either 800 or 900 MHz band is not relevant. TRAI also reiterated its earlier recommendations that entire available spectrum (2*35 MHz) in the 700 MHz band should be put to auction in the upcoming auction.

2.5 GOI had accepted the above recommendation and the entire available spectrum (2*35 MHz) in the 700 MHz was put to auction in 2016 Auction at the proposed Reserve Price of respective LSAs. However, the entire spectrum was unsold in 2016 Auction. Thus, it indicates that the reserve price was not accepted by the market.

In view of above development, TRAI may consider and give fresh recommendation on the reserve price, quantum of spectrum to be auctioned and other related issues for 700 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

3. 800 MHz Band:

3.1 A total quantum of 73.75 MHz spectrum was put to auction in 800 MHz band in the block size of 1.25 MHz in 19 LSAs in October 2016 auction. Out of 73.75 MHz spectrum, 15.0 MHz spectrum was sold in 4 LSAs only and the remaining 58.75 MHz

of spectrum was unsold in 19 LSAs. Out of these 4 LSAs where bids were received, only in 3 LSAs bids was higher than the Reserve Price. The details are given as below:

S. No.	Detail	Quantum of spectrum & No. of LSAs	Name of LSAs
1.	Spectrum put to Auction	73.75 MHz in 19 LSAs	All the LSAs except Assam, J&K and NE
2.	Spectrum sold	15.0 MHz in 4 LSAs	Gujarat, Punjab, Rajasthan, and UP (E)
3.	SP > RP	3 LSAs	Gujarat, Punjab and Rajasthan
4.	Unsold spectrum	58.75 MHz in 19 LSAs	All the LSAs except Assam, J&K and NE

3.2 The unsold spectrum of 58.75 MHz spectrum in 19 LSAs is available for the forthcoming auction.

In view of above development, TRAI may consider and give fresh recommendation on the reserve price and other related issues for 800 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

4. 900 MHz Band:

4.1 A total quantum of 9.4 MHz (FDD) spectrum was put to auction in 900 MHz band in the block size of 0.2 MHz in 4 LSAs [Bihar, Gujarat, UP(East) and UP(West)] in October 2016 auction. No bids were received in Auction 2016. Entire unsold spectrum of 9.4 MHz is available for forthcoming auction.

4.2 It may be mentioned that service license of M/s Aircel Limited in Tamil Nadu (including Chennai) service area is expiring in December 2018. M/s Aircel is holding administratively assigned spectrum in 900 MHz and 1800 MHz bands as given below:

Service area	900 MHz	1800 MHz
Tamil Nadu excluding Chennai	7.8 MHz	2.0 MHz
Chennai only	6.2 MHz	2.4 MHz

4.2.1 Spectrum to be released due to expiry would be 7.8 MHz in Tamil Nadu (Excluding Chennai) and 6.2 MHz in Chennai. Therefore, 6.2 MHz spectrum in 900 MHz band can be put to auction in Tamil Nadu (including Chennai service area). This amounts to partial spectrum in Tamil Nadu LSA including Chennai. The principle of charging partial spectrum has been prescribed in various Notice for Inviting Applications (NIAs).

4.3 It may further be mentioned that spectrum allotted in 1800 MHz band in Tamil Nadu service area has been exceeded about 4.4 MHz beyond 55 MHz allocated for

telecom services in the band. Spectrum to be released due to expiry of service license in 1800 MHz band will not be proposed to put in the forthcoming auction. This spectrum will be given to Defence.

4.4 It is proposed spectrum to be released due to expiry of service license of M/s Aircel Limited in Tamil Nadu (including Chennai) service area in 900 MHz band may be included in the forthcoming auction.

4.5 The availability in 900 MHz band after taking into account would be increased to 15.6 MHz as per detail given below:

S. No.	Service Area	Available Spectrum
1.	Bihar	4.6 MHz
2.	Gujarat	3.0 MHz
3.	Tamil Nadu	6.2 MHz
4.	UP(East)	0.6 MHz
5.	UP(West)	1.2 MHz

In view of above development, TRAI may consider and give fresh recommendation on the reserve price and other related issues for 900 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

5. 1800 MHz Band:

5.1 A total of 221.6 MHz (FDD) spectrum was put to auction in 1800 MHz band in the block size of 0.2 MHz in all the LSAs except Tamil Nadu. Out of which, 174.8 MHz spectrum was sold in 19 LSAs and the remaining 46.8 MHz spectrum was unsold in 13 LSAs. Out of these 19 LSAs where spectrum was sold, only in 6 LSAs bids was higher than the Reserve Price and entire spectrum was sold only in 8 LSAs. A detail is given below:

S.No.	Detail	Quantum of spectrum & No. of LSAs	Name of LSAs
1.	Spectrum put to Auction	221.6 MHz spectrum in 21 LSAs	All LSAs except Tamil Nadu
2.	Spectrum sold	174.8 MHz in 19 LSAs	All LSAs except Tamil Nadu, Odisha and Karnataka
3.	Fully Qty. Sold	8 LSAs	Haryana, Kolkata, MP, Maharashtra, Mumbai, NE, Rajasthan, UP (E) & UP (W)
4.	SP > RP	6 LSAs	Haryana, Kolkata, Mumbai, Rajasthan, UP (E) & UP (W)
5.	Unsold spectrum	46.8 MHz in 13 LSAs	AP, Assam, Bihar, Delhi, Gujarat, HP, J&K, Karnataka, Kerala, Maharashtra, Odisha, Punjab and West Bengal

5.2 Therefore, unsold spectrum of 46.8 MHz in 13 LSAs is available for the forthcoming auction.

In view of above development, TRAI may consider and give fresh recommendation on the reserve price and other related issues for 1800 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

6. 2100 MHz Band:

6.1 A total of 360 MHz spectrum was put to auction in 2100 MHz band in the block size of 5.0 MHz in all the 22 LSAs in the October 2016 auction. Out of which, 85 MHz spectrum was sold in 12 LSAs and the remaining 275 MHz spectrum in 21 LSAs was unsold. In all 12 LSAs bids was received at the Reserve Price and in 1 LSA i.e. Rajasthan, entire spectrum was sold. A detail is given below:

S.No.	Detail	Quantum of spectrum & No. of LSAs	Name of LSAs
1.	Spectrum put to Auction	360.0 MHz in 22 LSAs	All the 22 LSAs
2.	Spectrum sold	85.0 MHz in 12 LSAs	Bihar, Delhi, Haryana, J&K, Kerala, Maharashtra, Mumbai, Odisha, Punjab, Rajasthan, TN, & UP (E).
3.	Fully Qty. Sold	1 LSA	Rajasthan
4.	SP > RP	0	
5.	Unsold spectrum	275 MHz in 13 LSAs	All the LSAs except Rajasthan

6.2 Therefore, unsold spectrum of 275 MHz in 21 LSAs is available for the forthcoming auction.

In view of above development, TRAI may consider and give fresh recommendation on the reserve price and other related issues for 2100 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

7. 2300 MHz Band:

7.1 A total of 320 MHz spectrum in 2300 MHz band in the block size of 10 MHz in 16 LSAs was put to auction. Entire spectrum was sold. Therefore, no unsold spectrum is available in this band for forthcoming auction.

7.2 It may be mentioned that 2300 MHz band is spread from 2300 MHz to 2400 MHz making a total of 100 MHz spectrum. Out of this 100 MHz spectrum, 40 MHz spectrum each in all the 22 LSAs was sold in the spectrum auction held in May 2010.

Another 20 MHz spectrum each was put to auction in 16 LSAs in October 2016 auction and entire spectrum was sold.

7.3 There are several point to point links, assigned to PSUs and State Electricity Boards long back, are working in the remaining 40 MHz spectrum in this band. Out of this 40 MHz spectrum in the band, 20 MHz spectrum Pan India is to be given to Defence and the remaining 20 MHz spectrum in 16 LSAs and 40 MHz spectrum in 6 LSAs could be made available for telecom services subject to relocation of existing users to some other band. At present, no vacant spectrum is available.

In view of above development, TRAI may consider and give fresh recommendation on the reserve price and other related issues for 2300 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

8. 2500 MHz Band:

8.1 A total of 600 MHz spectrum was put to auction in 2500 MHz band in the block size of 10.0 MHz in all the 22 LSAs in the October 2016 auction. Out of which, 370 MHz spectrum was sold in 20 LSAs and the remaining 230 MHz spectrum in 12 LSAs was unsold. Out of these 20 LSAs where spectrum was sold, only 1 LSA i.e Kerala, bid price was higher than the Reserve Price. Moreover, entire spectrum, put to auction, was sold 10 LSAs. A detail is given below:

S.No.	Detail	Quantum of spectrum & No. of LSAs	Name of LSAs
1.	Spectrum put to Auction	600.0 MHz in 22 LSAs	All the 22 LSAs
2.	Spectrum sold	370.0 MHz in 20 LSAs	All the LSAs except Karnataka and Tamil Nadu
3.	Fully Qty. Sold	10 LSAs	Assam, Haryana, Kerala, MP, NE, Odisha, Rajasthan, UP (E), UP (W) & WB
4.	SP > RP	1 LSA	Kerala
5.	Unsold spectrum	230 MHz in 12 LSAs	AP, Bihar, Delhi, Gujarat, HP, J&K, Karnataka, Kerala, Kolkata, Maharashtra, MP and Punjab

8.3 Therefore, unsold spectrum of 230 MHz in 12 LSAs is available for the forthcoming auction.

In view of above development, TRAI may consider and give fresh recommendation on the reserve price and other related issues for 2500 MHz band. The details of available spectrum in various LSAs are enclosed as Annexure-I.

10. New Bands for auction:

10.1 The spectrum bands 3300-3400 MHz and 3400-3600 MHz are proposed for providing access services. The details of availability and other related issues in these two bands are as under:

10.2 3300-3400 MHz Band:

10.2.1 Allotment of spectrum in this band has been given to various Internet Service Providers (ISPs) up to 2012 in various districts of a service area. Their assignments are being renewed on annual basis.

10.2.2 It may be mentioned that some of the ISPs, assigned spectrum in this band (3300-3400 MHz), have also been assigned spectrum for internet services in some other bands (e.g. 2.7-2.9 GHz, 5.7 GHz and 10.0 GHz). Details of the assignments are placed in the file. The entire band can be made available for telecom services subject to relocation/ shifting of existing operations of the ISPs in 3300-3400 MHz to other bands. A case for harmonisation/ vacation of this band is being initiated and it is expected that entire band will be made available for telecom services by the end of this year.

10.2.3 Therefore, it is proposed to include 100 MHz in all the 22 LSAs in 3300-3400 MHz band in the forthcoming auction.

10.2.4 Recommendation of the TRAI for Policy for the rates of SUC (Spectrum Usage Charges), percentage AGR etc. applicable to the ISPs is already sought vide letter No. P-11014/032012- PP (pt) dated 25-06-2014 and last input provided vide letter of even no. dated 02-03-2016. TRAI is requested to provide recommendation on the issue of allotment of spectrum to ISPs, in general.

10.3 3400 – 3600 MHz:

10.3.1 The entire band is of 200 MHz. Out of this 200 MHz available spectrum, 25 MHz spectrum (i.e. 3400 -3425 MHz) is identified for ISRO's use in Indian Regional Navigation Satellite System (IRNSS). The remaining 175 MHz (3425-3600 MHz) spectrum is available for access services and the same can be put in the forthcoming auction.

10.4 It may be mentioned that as per National Frequency Allocation Plan 2011, these two frequency bands have already been identified for IMT services. Provisions in NFAP are as under:

IND65: Requirements of Broadband Wireless Access (BWA) applications may be considered in the frequency band 3.3 – 3.4 GHz on a case-by-case basis.

IND66: The requirement of IMT including Broadband Wireless Access (BWA) in the frequency band 3400-3600 MHz may be considered for coordination on a case-by-case

basis subject to availability of spectrum in this band and appropriate protection from out of band emission to the networks in the FSS in the frequency band 3600- 4200 MHz.

10.5 As per Recommendations ITU-R M.1036-5, the following two plans have been proposed for 3400-3600 MHz band.

(i) Time Division Duplex (TDD): 3400 – 3600 MHz (200 MHz)
(ii) Frequency Division Duplex (FDD): 3410-3490/3510-3590 MHz (80+80 MHz)

10.5.1 As per the final acts of World Radiocommunications Conference (WRC) 2015 that the frequency band 3300-3400 MHz is identified for the implementation of International Mobile Telecommunications (IMT) in accordance with Resolution 223 (Rev. WRC-15). WRC 2015 was held during November 2015. No ITU recommended band plan is yet available for 3300-3400 MHz band.

In view of above development, TRAI may consider and give recommendation on the reserve price quantum of spectrum to be put to auction, block size, band plan and other related issues for 3300-3400 MHz and 3400-3600 MHz bands.

11. The consolidated list of License Service Area wise availability of spectrum in various bands is at Annexure-I.

12. TRAI is, therefore, requested to:

(a) Provide recommendations on applicable reserve price, quantum of spectrum to be auctioned and associated conditions for auction of spectrum in 700 MHz, 800 MHz, 900 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands for all the LSAs under the terms of clause 11 (1)(a) of TRAI Act, 1997 as amended by TRAI Amendment Act 2000.

(b) Any other recommendations deemed fit for the purpose of forthcoming spectrum auction in 2017.

This issues with the approval of the competent authority.

Christopher
19/4/17

(V. J. Christopher)
Sr. Deputy Wireless Adviser to the Govt. of India

Available spectrum in various bands

S. No.	Name of LSA	FDD Bands					TDD Bands		No Band Plan	
		700 MHz	800 MHz	900 MHz	1800 MHz	2100 MHz	2300 MHz	2500 MHz	3300 MHz*	3400 MHz**
1	Andhra Pradesh	35.00	7.50		2.00	20.00		30.00	100.00	175.00
2	Assam	35.00			3.00	15.00			100.00	175.00
3	Bihar	35.00	2.50	4.60	0.40	10.00		10.00	100.00	175.00
4	Delhi	35.00	2.50		10.80	15.00		20.00	100.00	175.00
5	Gujarat	35.00	1.25	3.00	1.60	15.00		10.00	100.00	175.00
6	Haryana	35.00	1.25			10.00			100.00	175.00
7	Himachal Pradesh	35.00	3.75		5.80	20.00		10.00	100.00	175.00
8	Jammu & Kashmir	35.00			9.60	10.00		10.00	100.00	175.00
9	Karnataka	35.00	2.50		4.20	15.00		40.00	100.00	175.00
10	Kerala	35.00	2.50		1.40	10.00		0.00	100.00	175.00
11	Kolkata	35.00	2.50			15.00		20.00	100.00	175.00
12	Madhya Pradesh	35.00	2.50			15.00			100.00	175.00
13	Maharashtra	35.00	7.50		1.40	10.00		10.00	100.00	175.00
14	Mumbai	35.00	5.00			15.00		20.00	100.00	175.00
15	North East	35.00				15.00			100.00	175.00
16	Odisha	35.00	3.75		1.40	15.00			100.00	175.00
17	Punjab	35.00	2.50		4.40	10.00		10.00	100.00	175.00
18	Rajasthan	35.00	2.50						100.00	175.00
19	Tamil Nadu	35.00	2.50	6.20		5.00		40.00	100.00	175.00
20	Uttar Pradesh (East)	35.00	2.50	0.60		5.00			100.00	175.00
21	Uttar Pradesh (West)	35.00	2.50	1.20		15.00			100.00	175.00
22	West Bengal	35.00	1.25		0.80	15.00			100.00	175.00
	Total	**770.00**	**58.75**	**15.60**	**46.80**	**275.00**		**230.00**	**2200.00**	**3850.00**

Christopher
19/4/17

Annexure 1.2

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination Wing
6th floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi-110001.

No.: L-14006/01/2017-NTG Date: 23.07.2018

To,

The Secretary
Telecom Regulatory Authority of India
Mahanagar Doorsanchar Bhawan
Jawahar Lal Nehru Marg (Old Minto Road)
New Delhi - 110002.

Subject: **TRAI recommendations on the Reserve Price for auction of right to use spectrum in 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3300-3400 MHz and 3400-3600 MHz bands.**

Sir,

I am directed to refer to your letter No. 103-1/2017-NSL-II dated 21.05.2018, and No. 15.01/2017-F&EA dated 04.07.2018, on the above-mentioned subject and to say that the following information, as sought by you, is enclosed herewith:

i. Details of quantum of spectrum traded/shared by the TSPs LSA-wise, and, the amount received on account of spectrum trading/spectrum sharing, LSA-wise operator-wise by DoT and rates at which trading or sharing has taken place (Annexure-I & II).

ii. Latest data on availability of spectrum (band-wise, LSA-wise) available for forthcoming spectrum auction (Annexure-III).

2. It may further be informed that the exercise of harmonization of spectrum in 900 MHz band is going on in this Ministry. Additional spectrum in the range of 0.8 MHz to 4.6 MHz in 900 MHz band is likely to be made available for auction in certain LSAs after vacation of Defense operations from this band.

3. It may also be noted that Reliance Communications Limited has defaulted in payment of installments in the months of March and April-2018, due towards deferred payments in respect of spectrum auctions held in 2013 and 2015. Consequently, a Show Cause Notice was issued to the licensee for termination of spectrum assignments. Currently, the matter is under consideration in the department.

DAK Received on
24 JUL 2018
TELECOM REGULATORY AUTHORITY OF INDIA
NEW DELHI

RECEIVED
24 JUL 2018
PIC/WPC

4. It may further be noted that the bankruptcy petition of Aircel group is under consideration in National Company Law Tribunal (NCLT). Spectrum holding of Aircel group is likely to be changed after the matter is finalized.

5. In consequence to the events mentioned in para 2, 3 and 4 above, additional spectrum available for auction will be communicated by the department subject to the outcome of these events.

This issues with the approval of the competent authority.

Encl: As above.

(Sukhpal Singh)
Joint Wireless Adviser to the Govt. of India

Annexure-III

Spectrum available in various Bands

Sl. No.	Service Area	700 MHz	800 MHz	900 MHz	1800 MHz	2100 MHz	2300 MHz	2500 MHz	3300-3400 MHz	3400-3600 MHz
		(Band Plan : FDD)					(Band Plan : TDD)		No Band Plan	
1	Andhra Pradesh	35.00	7.50		6.40	20.00	20.00	30.00	100.00	175.00
2	Assam	35.00			3.00	15.00	20.00		100.00	175.00
3	Bihar	35.00	2.50	4.60	0.40	10.00	20.00	10.00	100.00	175.00
4	Delhi	35.00	2.50		15.20	15.00	20.00	20.00	100.00	175.00
5	Gujarat	35.00	1.25	3.00	6.00	15.00	20.00	10.00	100.00	175.00
6	Haryana	35.00	1.25	0.20**	8.80	10.00	40.00		100.00	175.00
7	Himachal Pradesh	35.00	3.75		10.20	20.00	20.00	10.00	100.00	175.00
8	Jammu and Kashmir	35.00			14.00	10.00	40.00	10.00	100.00	175.00
9	Karnataka	35.00	2.50	0.20**	8.60	15.00	20.00	40.00	100.00	175.00
10	Kerala	35.00	2.50		5.80	10.00	20.00		100.00	175.00
11	Kolkata	35.00	2.50		6.20	15.00	20.00	20.00	100.00	175.00
12	Madhya Pradesh	35.00	2.50		4.40	15.00	20.00		100.00	175.00
13	Maharashtra	35.00	7.50		10.20	10.00	20.00	10.00	100.00	175.00
14	Mumbai	35.00	5.00		4.20	15.00	20.00	20.00	100.00	175.00
15	North East	35.00				15.00	20.00		100.00	175.00
16	Orissa	35.00	3.75		1.40	15.00	20.00		100.00	175.00
17	Punjab	35.00	2.50		8.80	10.00	40.00	10.00	100.00	175.00
18	Rajasthan	35.00	2.50		4.40		40.00		100.00	175.00
19	Tamilnadu	35.00	2.50	6.20	2.20	5.00	20.00	40.00	100.00	175.00
20	Uttar Pradesh (East)	35.00	2.50	0.60	4.40	5.00	40.00		100.00	175.00
21	Uttar Pradesh (West)	35.00	2.50	1.20	8.80	15.00	40.00		100.00	175.00
22	West Bengal	35.00	3.75*		0.80	15.00	20.00		100.00	175.00
	Total	**770.00**	**61.25**	**16.00**	**134.20**	**275.00**	**560.00**	**230.00**	**2200.00**	**3850.00**

* In West Bengal LSA, 3 carriers are available in 800 MHz band. However, 2 carriers are available without guard band and only 1 carrier is available with guard band of 0.3 MHz which was put to auction in the year 2016 and was unsold.

** In each of Haryana and Karnataka LSAs, only 0.2 MHz spectrum is available in 900 MHz band which was not put to auction in the year 2016.

Note: Spectrum availability in 700, 800, 900, 1800, 2100 MHz bands is shown as paired bandwidth i.e. 35.00 MHz availability means 35+35 MHz including both uplink and downlink spectrum.

Annexure 3.1

PROJECTED GROWTH RATES

	Subscribers Growth	Revenue Growth	Growth of Voice MOU per subscriber per month	Growth of SMS per subscriber per month	Growth of Data per subscriber per month
2018-19	2.00%	0.50%	0.00%	0.00%	20.00%
2019-20	2.50%	3.00%	0.00%	0.00%	18.00%
2020-21	3.00%	4.00%	0.00%	0.00%	16.00%
2021-22	3.00%	6.00%	0.00%	0.00%	14.00%
2022-23	2.50%	5.00%	0.00%	0.00%	12.00%
2023-24	2.00%	4.50%	0.00%	0.00%	10.00%
2024-25	1.50%	4.00%	0.00%	0.00%	10.00%
2025-26	1.50%	3.50%	0.00%	0.00%	8.00%
2026-27	1.00%	3.50%	0.00%	0.00%	8.00%
2027-28	1.00%	3.00%	0.00%	0.00%	8.00%
2028-29	0.75%	2.50%	0.00%	0.00%	6.00%
2029-30	0.75%	2.50%	0.00%	0.00%	6.00%
2030-31	0.50%	2.00%	0.00%	0.00%	6.00%
2031-32	0.50%	2.00%	0.00%	0.00%	4.00%
2032-33	0.50%	2.00%	0.00%	0.00%	4.00%
2033-34	0.50%	2.00%	0.00%	0.00%	4.00%
2034-35	0.50%	1.00%	0.00%	0.00%	2.00%
2035-36	0.50%	1.00%	0.00%	0.00%	2.00%
2036-37	0.50%	0.50%	0.00%	0.00%	2.00%
2037-38	0.50%	0.50%	0.00%	0.00%	2.00%

Annexure 3.2

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 1800 MHz SPECTRUM

(Rs. in crore)

LSA	Achieved Price - October 2016 auction (duly indexed) of 1800 MHz	Producer Surplus Model	Production function Model	Multiple Regression	Revenue Surplus Model	Average (mean) Value
Delhi	457.42	336.03	206.13	713.00	127.76	**368.07**
Mumbai	560.82	260.52	139.15	439.00	93.06	**298.51**
Kolkata	173.28	75.07	36.41	95.00	28.24	**81.60**
Andhra Pradesh	278.58	147.62	91.03	489.00	161.96	**233.64**
Gujarat	272.85	208.18	73.33	423.00	84.23	**212.32**
Karnataka		162.55	95.56		152.45	**136.85**
Maharashtra	364.56	237.52	105.07	726.00	145.74	**315.78**
Tamilnadu		131.38	93.94		148.26	**124.53**
Haryana	56.52	47.22	22.80	57.00	26.85	**42.08**
Kerala	95.15	101.58	46.93	192.00	125.25	**112.18**
Madhya Pradesh	95.15	167.09	64.25	112.00	71.42	**101.98**
Punjab	88.27	163.54	39.73	114.00	68.96	**94.90**
Rajasthan	105.36	153.34	65.97	110.00	64.24	**99.78**
U. P. (East)	152.64	218.56	80.00	95.00	81.61	**125.56**
U.P. (West)	114.99	109.73	60.03	79.00	50.96	**82.94**
West Bengal	52.73	59.55	46.53	48.00	35.81	**48.53**
Assam	45.86	47.63	26.62	45.00	38.36	**40.69**
Bihar	71.08	244.28	75.73	90.00	66.53	**109.52**
Himachal Pradesh	18.34	16.00	12.73	17.00	12.24	**15.26**
Jammu&Kashmir	14.90	32.37	22.78	14.00	21.60	**21.13**
North East	12.61	37.68	14.50	19.00	23.76	**21.51**
Orissa		46.50	30.97		23.85	**33.77**

Annexure 3.3

VALUATION (PER MHz) USING DIFFERENT APPROACHES - 900 MHz

(Rs. in crore)

LSA	Economic premium over 1800 MHz plus average valuation of 1800 MHz band	1.5 times of average valuation of 1800 MHz band	2 times of average valuation of 1800 MHz band	Auction determined price of 800 MHz band(October 2016 duly indexed)	Average (mean) Value
Gujarat	524.31	409.27	545.69	384.56	**465.96**
Karnataka	413.40	205.28	273.71		**297.46**
Tamilnadu	443.55	186.79	249.06		**293.13**
Haryana	184.56	84.78	113.04		**127.46**
U. P. (East)	522.40	228.97	305.29	251.06	**326.93**
U.P. (West)	388.18	172.48	229.97		**263.54**
Bihar	370.07	164.29	219.05		**251.13**

Annexure 3.4

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 800 MHz

(Rs. in crore)

LSA	Auction determined price - October 2016 (duly indexed) auction of 800 MHz	1.5 times of average valuation of 1800 MHz band	2 times of average valuation of 1800 MHz band	Average (mean) Value
Delhi		686.13	914.84	**800.48**
Mumbai		841.24	1121.65	**981.44**
Kolkata		259.92	346.56	**303.24**
Andhra Pradesh		417.87	557.16	**487.51**
Gujarat	384.56	409.27	545.69	**446.51**
Karnataka		205.28	273.71	**239.49**
Maharashtra		546.84	729.12	**637.98**
Tamilnadu		186.79	249.06	**217.92**
Haryana		84.78	113.04	**98.91**
Kerala		168.28	224.37	**196.32**
Madhya Pradesh		152.97	203.96	**178.47**
Punjab	156.70	142.35	189.80	**162.95**
Rajasthan	265.94	158.03	210.71	**211.56**
U. P. (East)	251.06	228.97	305.29	**261.77**
U.P. (West)		172.48	229.97	**201.22**
West Bengal		79.10	105.47	**92.29**
Bihar		164.29	219.05	**191.67**
Himachal Pradesh		27.51	36.69	**32.10**
Orissa		50.66	67.54	**59.10**

Annexure 3.5

VALUATION (PER MHz) USING DIFFERENT APPROACHES – 2100 MHz SPECTRUM

(Rs. in crore)

LSA	Auction Determined Price October 2016 (duly indexed) of 2100 MHz	0.83 times of average valuation of 1800 MHz band	Average (mean) Value
Delhi	635.11	379.66	**507.38**
Mumbai	528.50	465.48	**496.99**
Kolkata		143.82	**143.82**
Andhra Pradesh		231.22	**231.22**
Gujarat		226.46	**226.46**
Karnataka		113.59	**113.59**
Maharashtra	390.93	302.58	**346.76**
Tamilnadu	394.37	103.36	**248.86**
Haryana	63.05	46.91	**54.98**
Kerala	202.91	93.11	**148.01**
Madhya Pradesh		84.65	**84.65**
Punjab	104.32	78.77	**91.55**
U. P. (East)	126.11	126.70	**126.40**
U.P. (West)		95.44	**95.44**
West Bengal		43.77	**43.77**
Assam		38.06	**38.06**
Bihar	98.59	90.90	**94.75**
Himachal Pradesh		15.22	**15.22**
Jammu & Kashmir	12.61	17.54	**15.08**
North East		17.85	**17.85**
Orissa	43.56	28.03	**35.80**

Annexure 3.6

RESERVE PRICE PER MHz: COMPARISON OF 80% OF AVERAGE VALUATION PER MHZ OF 1800 MHZ SPECTRUM WITH OCTOBER 2016 (INDEXED) AUCTION REVEALED PRICE

(Rs. in crore)

LSA	Category	80% of average valuation per MHz of 1800 MHz spectrum	Auction revealed price per MHz of 1800 MHz spectrum October 2016 (duly indexed)	Reserve Price per MHz: Higher of 80% of recommended average valuation or achieved price October 2016 indexed*
Delhi	Metro	365.93	457.42	457.42
Mumbai	Metro	448.66	560.82	560.82
Kolkata	Metro	138.62	173.28	173.28
Andhra Pradesh	A	222.86	278.58	278.58
Gujarat	A	218.28	272.85	272.85
Karnataka	A	109.48		109.48
Maharashtra	A	291.65	364.56	364.56
Tamilnadu	A	99.62		99.62
Haryana	B	45.21	56.52	56.52
Kerala	B	89.75	95.15	95.15
Madhya Pradesh	B	81.59	95.15	95.15
Punjab	B	75.92	88.27	88.27
Rajasthan	B	84.28	105.36	105.36
U. P. (East)	B	122.12	152.64	152.64
U.P. (West)	B	91.99	114.99	114.99
West Bengal	B	42.19	52.73	52.73
Assam	C	36.69	45.86	45.86
Bihar	C	87.62	71.08	87.62
Himachal Pradesh	C	14.67	18.34	18.34
Jammu & Kashmir	C	16.91	14.90	16.91
North East	C	17.21	12.61	17.21
Orissa	C	27.02		27.02

* if auction determined price of October 2016 not available, then lower of 80% of recommended average valuation or previous recommended Reserve price (January 2016) where spectrum was put to auction else 80% of recommended average valuation

Annexure 3.7

RESERVE PRICE PER MHz: COMPARISON OF 80% OF AVERAGE VALUATION PER MHZ OF 800 MHZ SPECTRUM WITH OCTOBER 2016 AUCTION REVEALED PRICE

(Rs. in crore)

LSA	Category	80% of average valuation per MHz of 800 MHz spectrum	October 2016 Auction revealed price per MHz of 800 MHz spectrum	Reserve Price per MHz: Higher of 80% of recommended average valuation or October 2016 auction revealed price*
Delhi	Metro	640.39		640.39
Mumbai	Metro	785.15		727.00
Kolkata	Metro	242.59		160.00
Andhra Pradesh	A	390.01		390.01
Gujarat	A	357.21	384.56	384.56
Karnataka	A	191.59		191.59
Maharashtra	A	510.38		510.38
Tamilnadu	A	174.34		174.34
Haryana	B	79.13		57.00
Kerala	B	157.06		157.06
Madhya Pradesh	B	142.78		142.78
Punjab	B	130.36	156.70	156.70
Rajasthan	B	212.76	265.94	265.94
U. P. (East)	B	209.42	251.06	251.06
U.P. (West)	B	160.98		160.98
West Bengal	B	73.83		73.83
Bihar	C	153.33		136.00
Himachal Pradesh	C	25.68		24.00
Orissa	C	47.28		47.28

* if auction determined price of October 2016 not available, then lower of 80% of recommended average valuation or previous recommended Reserve price (January 2016) where spectrum was put to auction else 80% of recommended average valuation

Annexure 3.8

RESERVE PRICE PER MHz: COMPARISON OF 80% OF AVERAGE VALUATION PER MHZ OF 2100 MHZ SPECTRUM WITH OCTOBER 2016 AUCTION REVEALED PRICE

(Rs. in crore)

LSA	Category	80% of average valuation per MHz of 2100 MHz spectrum	October 2016 Auction revealed price per MHz of 2100 MHz spectrum	Reserve Price per MHz: Higher of 80% of recommended average valuation or October 2016 auction revealed price*
Delhi	Metro	508.09	635.11	635.11
Mumbai	Metro	422.80	528.50	528.50
Kolkata	Metro	115.06		115.06
Andhra Pradesh	A	184.98		184.98
Gujarat	A	181.17		181.17
Karnataka	A	90.87		90.87
Maharashtra	A	312.74	390.93	390.93
Tamilnadu	A	315.49	394.37	394.37
Haryana	B	50.44	63.05	63.05
Kerala	B	162.33	202.91	202.91
Madhya Pradesh	B	67.72		67.72
Punjab	B	83.46	104.32	104.32
U. P. (East)	B	101.12	126.11	126.11
U.P. (West)	B	76.35		76.35
West Bengal	B	35.02		35.02
Assam	C	30.45		30.45
Bihar	C	78.87	98.59	98.59
Himachal Pradesh	C	12.18		12.18
Jammu & Kashmir	C	12.06	12.61	12.61
North East	C	14.28		12.00
Orissa	C	34.85	43.56	43.56

* if auction determined price of October 2016 not available, then lower of 80% of recommended average valuation or previous recommended Reserve price (January 2016) where spectrum was put to auction